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ECONOMIC GEOGRAPHY

JULY

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HIGH COUNTRY "RUN." THE GEOGRAPHY OF EXTENSIVE PASTORALISM IN NEW ZEALAND

K. B. Cumberland

DEVELOPMENT OF THE LAGUNA REGION

Lorene A. Garloch

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Dr. Schwendeman, Head of the Department of Geography at University of Kentucky, Lexington, Kentucky, formerly of State Teachers College, Moorhead, Minnesota, is particularly interested in the relation of water supply to farm economy in the Red River Valley of the North.

Dr. Stratton, Assistant Professor of History and Government at Denison University, Granville, Ohio, concludes an article begun in the last issue.

Mr. Cumberland of Canterbury University College, Christchurch, is lecturer in the first geography department to be initiated in New Zealand.

Miss Garloch, Chief of Reference and Circulation of the Library of the University of Pittsburgh, contributes in this issue the second of a series of three articles on cotton production in Mexico. The third and final article in this series will appear in an early issue.

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FARM WATER

WATER is more important on the farm than anywhere else—water for drink for man and beast, water for crops, water for fire protection, water for power, water for a multiplicity of purposes. Where there is water enough, agriculture, the basic activity of the world's peoples and of their economy, flourishes, and supports a population that may be wholly rural, but more likely is in large part urban, nonagricultural. Where there is lack of water, only a pastoral economy is possible, and large cities with non-farming populations are few and far between.

Not only volume and quality, but trustworthiness of supply, form critical factors in farm water as one of the vital agricultural resources. Adequacy of water supply is never assured by periodicity or intermittency of source. Rainfall must not only be heavy, but it must be uniformly enough distributed in time to afford adequacy from one rain, one shower, to the next. Streams and wells for irrigation must be regular in their flow, steady in their volume if they are to lend themselves easily and economically to farm supply. Long seasons of drought that dessicate soil, or dry up springs and streams, must not intervene between rains, or farm economy suffers, perchance succumbs.

More important than fertility and tilth of soil are adequacy and trustworthiness of moisture supply to all the diverse practices of the farm,—meadow and pastoral use of the land; crops and the growing of high yields of grains, fruits, fibers, or vegetables; herds of dairy or beef cattle, flocks of sheep, or droves of swine. All are dependent upon ample, even copious, supplies of farm water.

ECONOMIC GEOGRAPHY

VOL. 20 JULY, 1944 No. 3

WATER SUPPLY GEOGRAPHY OF THE BASIN OF THE RED RIVER OF THE NORTH IN THE UNITED STATES

J. R. Schwendeman

1. Introduction and Physical Geography of the Red River Basin
2. Water Supply and Farm Economy
3. The Organized Water Supply Systems of the Cities and Towns
4. Water Supply of the Incorporated Towns and Villages Without Organized Systems
5. Water Supply and the Progress of the Red River Basin

THE farm products of the Red River Basin play a vital role in the world at all times in supplying surplus food products and is especially important in the present emergency of war. A large surplus production of grains, meats, dairy products, eggs, potatoes, beet sugar, onions, flax, and hay leave the valley for other areas of deficiency and need.

Table I emphasizes this surplus production of the Red River Basin by comparing it with the other states of the United States. The Red River Basin is like an oasis thrust into the unproductive frontiers of cold, aridity, and swamp land of the north central part of the United States (Figure 1). To the west aridity limits general farming. On the east the swampland of Minnesota practically exclude farming, and to the north the short cool growing seasons rapidly reduce diversified farming enterprises. The area of the Basin taken as a basis for compiling the agricultural data of Table I is 42,701 square miles or about two-thirds the size of the average state and ranks thirty-third in area among the states. The actual area drained by the Red River system is 35,520 square miles. The Basin is sparsely populated as compared with the average state having a total of 513,182 people. This is only about one-fifth of the average state population and in rank is near the bottom at forty-fourth.

In spite of its smaller area and population the Basin ranks above average among the states in eight of its eighteen prominent farm products and stands high in the production of all eighteen. Moreover its farm products rank highest from the standpoint of world demand. They are staple products of general desire and need.

Few other areas of equal size produce more bushels of high quality wheat. The 76 million bushels production in 1942 placed it third in the United States. Kansas, the leading state outranked it by producing 173 million

NOTE: This series of articles is based on research conducted by the author of the water supply of the world famous farming region known as the "Red River Valley of the North." This study was confined to that part of the Red River Basin lying south of the Canadian border and in the United States (Figures 1 and 2).

TABLE I

A comparison of the Red River of the North as a farming region with the states of the United States. Statistics are selected from the Sixteenth Census of the United States, years 1939 or 40 and wherever county data were available statistics for the years 1941 or 42 were selected from the publications of the United States Department of Agriculture. The data were compiled from 42 counties either wholly or partly in the Basin. Eight counties with small fractions of their area within the basin were omitted. Nevertheless a good picture of the agriculture status of the Basin is presented.

Item	*Red River Basin*	*Average State*	*Rank of Red River Basin Among the 48 States*	*Leading State*	
Area	(a) 42,701	64,344	33	Texas	267,339
Sq. Miles	(b) 35,520	.....	..	.....	.....
Population	513,182 (2)	2,743,110	44	N. Y.	13,479,142
No. of Farms	76,517	127,017	28	Texas	418,002
Average size	356 acres	174	11	Wyoming	1,806
Farms of 1000 acres and over	2,448	2,094	15	Texas	15,101
Farm income	$242,000,000	$263,854,000	20	Iowa	$922,498,000
Wheat (bu.)	76,273,600	19,707,000	3	Kan.	173,332,000
Barley (bu.)	42,826,000	7,452,000	4	Nebr	48,832,000
Oats (bu.)	49,888,000	24,502,000	11	Iowa	177,280,000
Corn (bu.)	28,857,000	50,605,000	23	Iowa	464,814,000
Rye (bu.)	8,816,000	941,000	2	N. D.	13,516,000
Hay, Tame (tons)	1,570,000	1,716,000	20	Wis.	6,720,000
Hay, Wild (tons)	1,967,000	245,000	2	Neb.	2,243,000
Flax	5,523,000	656,000	2	Minn.	14,858,000
Potatoes	23,129,000	7,454,000	4	Maine	44,745,000
Sugar Beets	139,000	215,000	..	Cal.	1,999,000
Cattle	1,310,000	1,554,312	22	Texas	7,444,000
Sheep	987,000	1,025,083	17	Texas	10,139,000
Swine	495,500	1,130,333	27	Iowa	9,048,000
Horses	53,264	212,792	37	Iowa	729,000
Chickens and Turkeys	16,219,000	22,916,000	26	Iowa	81,912,000
Milk (gals.)	257,585,000	279,792,000	17	Wis.	584,302,000
Butter sold (lbs.)	62,816,000	38,267,000	12	Minn.	311,153,000
Eggs (dozs.)	26,753,000	72,510,000	34	Iowa	190,250,000

Onions, hayseed, vegetables, and fruits are increasing in importance in the basin but can not yet be represented by statistics.

(1) North Dakota Agricultural Statistics, U. S. Dept. of Agriculture, Fargo, North Dakota.

(2) Population for the basin as compiled by the author from Sixteenth Census. Minor civil divisions were used and the population represents the drainage area fairly accurately.

(a) Total area of the counties of the basin which were used for agricultural statistics.

(b) Total area of the drainage area of the basin.

bushels with a state area of 82 thousand square miles. However, the Red River Basin's wheat production was listed at 99 million bushels in 1910 and this production could, under favorable conditions and demand, be duplicated and exceeded.

A production similar to wheat is maintained for all other major crops with the exception of corn, oats, and tame hay. Corn is a newcomer of the last twenty years and with the introduction of hardy hybrid stocks is rapidly gaining in rank. Tame hay is in a similar position with corn. Sugar beets, although not a major crop, can be expected to increase in production. The production of seed in all crops from onions to hay is another thriving and expanding farm enterprise.

The function of the level land and fertile soil of the Red River Basin in supporting this abundant and varied farm production is widely advertised. Not so well known is the fact that the 76,517 farmsteads of the basin depend almost exclusively upon a vast artesian system for water supply. Nor, is it generally known and appreciated that this artesian water supply is available almost anywhere in the Basin. Assuming the factors of soil fertility, level land, and climate to be stable or potentially stable, this artesian water supply

becomes the critical factor in the maintenance and progress of the Basin.

Economically, there is ample room for growth in the Basin. With the average farm at 356 acres in size and 2,448 farms over 1,000 acres large the farmsteads could probably double in number and still maintain the high living standards to which the midwestern farmer is accustomed. This potential expansion in farmsteads is based on the assumption that the climate will resume its steady trend previous to 1928; that economic fluctuations will level off at a fairly high level; and that the water supply can support the increasing demands of diversification.

A critical factor in the progress of the Basin is the lack of a really large water supply at any one place to support city growth. The larger cities depend upon the rivers. The rivers in this level area are small and slow flowing with no physically favorable spot for large reservoirs.

The question then arises: "what is the future for adequate water supply for both farm and city in the Red River Basin of the North?"

PHYSICAL GEOGRAPHY OF THE RED RIVER BASIN

Important physical factors in the water supply geography of the Red River Basin are: (1) Location in northern United States and central North America, (2) Large area, (3) Level to flat land with no prominent relief, (4) Small streams and slow drainage, (5) Deep mantle of glacial drift interspersed with hardpan and capped in the valley by the silts of Glacial Lake Agassiz, (6) The wide and deep valley trough cut by the pre-glacial Red River in the granite and sedimentary rocks which now lie beneath the present mantle of glacial drift and lake sediments, (7) The large store of ground water filling this great rock trough and held in storage by sands and gravels of the porous glacial drift, (8) The moderate, reliable, and year-round precipitation in rain and snow, (9) The temperate climate subject to rapid changes in weather with occasional extremes in both weather changes and climatic fluctuations, (10) The long, cold winters, (11) The absence of any vegetative covering excepting prairie grasses and crops.

Before expanding on the above factors a brief account of the geological history of the Basin appears desirable.

First, a great river flowed north to Hudson Bay along the same line as the present Red River. This river cut a deep and wide valley in the rocks forming the surface at that time. Next, down this valley moved one of the great ice lobes from the ice cap then extending over northern North America. This ice lobe deepened and smoothed this valley partly filling it with a drift of sand, gravel, clay, and boulders. Later, when the glacier receded the melt water from the ice formed a vast lake over the partly drift filled valley. This former lake is now referred to as Glacial Lake Agassiz. When the ice melted back beyond Hudson Bay the water of the lake drained out leaving its bottom exposed. The area covered by the waters of Glacial Lake Agassiz extended widely over what is now United States and Canada covering a surface of about 110,000 square miles or almost four times the area of the present Lake Superior. The flat central part of the lake bottom through which the present Red River flows is called the Red River Valley of the North. This flat part, with practically all the rest of the lake bottom and the lands draining into them, is in-

cluded in this study under the title of the Red River Basin.

LOCATION

The United States portion of the Red River Basin is located in almost the exact geographical center of the North American Continent between the parallel 45 degrees and 30 minutes and the 49th parallel (Figure 1). It is in the north central part of the United States and occupies part of western Minnesota, northeastern South Dakota, and eastern North Dakota (Figure 2).

AREA

The extent of the basin in the United States is given as 35,520 square miles distributed as follows: Minnesota 16,090 square miles, North Dakota 16,800 square miles, and South Dakota 670 square miles. The divide which limits the extent of the basin separates it from the Souris Basin on the northwest, the Missouri Basin on the west and southwest, the Mississippi Basin on the southeast and east, and the Rainy River and Lake of the Woods basins on the northeast. From south to north the basin is about 245 miles at its greatest length—which length is about the center of axial depression of the basin. Although the Red River does not meander widely, its minor windings are so numerous that it flows 397 miles before reaching the Canadian border. From east to west the basin is 300 miles wide at its widest point.

FIGURE 1.—The basin of the Red River of the North is almost in the exact center of North America with a northern outlet.

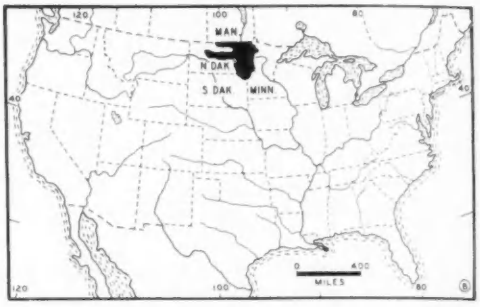


FIGURE 2.—The United States portion of the Red River Basin of the North has an area of 35,520 square miles.

The basin is for the most part a rolling plain varied only by the remarkably level lake plain of the so-called Red River Valley in its center. There are no marked heights and the peripheral elevations vary from 1,200 feet to 1,500 feet on the east and from about 1,400 feet to over 2,100 feet on the west.

The water sheds slope in a roughly concentric pattern from the divides to the basin's lowest elevation where the Red River enters Canada at 755 feet above mean sea level. The morainic surface on either side of the central valley is very irregular while, in striking contrast, the lake plain of the valley is one of the world's most uniform land surfaces. From the center of this plain outward absolutely no relief is visible to the eye (Figure 4). The land is as flat as a table top and the only change in surface noticeable is that

with distance. Only the tops of trees, homes, and other cultural prominences are seen on the far horizon because of the earth's curvature. The small stream valleys on the surface of the plain are so insignificant that they are not noticeable in looking over the plain. In the spring, water from melting snow spreads in wide sheets over the surface and does not disappear until the ground thaws and allows the water to sink.

Owing to the extreme youth of the basin both morainic upland and lacustrine plain are poorly drained, with lakes, swamps, and sloughs of common occurrence. The streams are few, small, and with no well defined pattern. In fact, the southerly course of the streams in the upland is reversed to a northerly course across the lake plain to join the Red River. The gradient or descent of the Red River to the north is very gentle, averaging a little less than one foot to the mile. Upham remarks, "So slight an inclination is inconsiderable to the eye, as is also the more considerable ascent, usually two or three feet to the mile for the first ten or fifteen miles to the east and west from the river." The river has cut only a channel 30 to 50 feet deep in this plain with no perceptible flood plains. Because of its low gradient the Red River has an extremely winding course formerly handicapping its value in navigation and at present being the

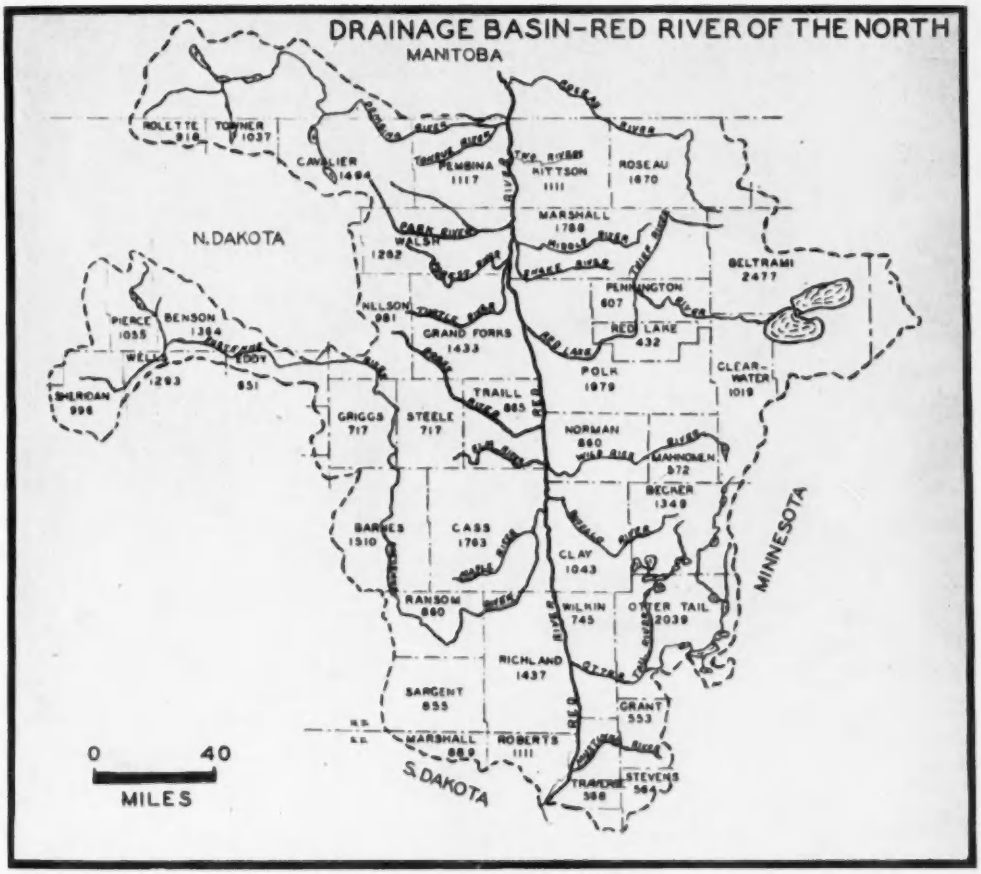


FIGURE 3.—Reference map of counties and rivers. Figures represent area in square miles of counties.

FIGURE 4.—Lacustrine Plain of Glacial Lake Agassiz. Fifteen miles east of Moorhead, Minnesota.

occasion of considerable loss of water because of the increased mileage the water has to flow. The streams on either side of the Red River are similar to the main stream as they cross the plain, mere trenches in the plain with winding courses and sluggish flow.

Swamps on the surface of the lake plain were formerly very extensive and are still numerous. Up to 1915, 3,262,386 acres of swampland had been drained in the Minnesota counties bordering the Red River according to Ben Palmer. This drainage lacked very little of being 100 per cent of the combined acreage for these counties. Present swamps and hayland are on the side of the lake plain immediately at the base of the beach ridges of glacial Lake Agassiz. The plains portion of the Red River's tributaries are practically useless except for drainage.

The major eastern tributaries to the Red River named from south to north are the Bois des Sioux, Mustinka, Otter Tail, Buffalo, Wild Rice, Red Lake, Snake, Two Rivers, and Roseau (Figure 3). Of these, the Otter Tail and Red Lake rivers are the most valuable for water supply and power. On the west from south to north the tributaries are the Wild Rice, Sheyenne, Goose, Park, and Pembina (Figure 3). The Sheyenne is by far the largest of these western streams in point of length. In the morainic uplands (Figure 5), these streams are much impeded by swamp and lake (Figure 6) and their courses are often little more than a succession of swamps and lakes, particularly in Minnesota. As they approach the valley, however, their flow quickens and the streams make the descent from the morainic uplands in a series of rapids and have cut fair sized ravines in the loose morainic and beach deposits (Figure 7). At the point of these rapids on the Minnesota side a line of fair sized towns have developed such as Fergus Falls, Red Lake Falls, and Thief River Falls. At these towns the rivers have been dammed for both water supply and power. The Dayton Hollow Reservoir and power plant of the Northern State Power Company is built on the Otter Tail just below Fergus Falls.

While the sluggish flow of these streams has diminished greatly their value for water supply and power, it has contributed much to the store of ground water by delaying the run-off and permitting maximum seepage into the loose glacial drift.

The climate of the basin is characterized by a moderate and fairly reliable rainfall, well distributed. The normal areal distribution is from 15 inches on the west to 24 inches in the uplands on the eastern side of the basin (Figure 8). In the 48 years preceding 1929, only ten years fell below twenty inches

at Moorhead in the south-central basin. The average departure of these ten years under twenty inches was 3.41 inches. Two years, 1910 and 1917, were extremely dry with 10.06 and 9.50 inches respectively and accounted for 70 per cent of the departure from normal rainfall up to 1929. All of the other 48 years were 16 inches and above. However, from 1929 to 1940 no single year reached 20 inches and one year (1936) was under 9 inches. This recent marked trend down from what was considered an established normal rainfall has occasioned considerable alarm and has initiated decided changes in water supply policies as visible supplies dwindled. However, since 1940 there has been a marked increase in rainfall.

The early summer maximum in rainfall, following the spring snow and ice melt water, is favorable to accumulating water reserves for the later and hotter summer months. As a rule torrential rains and summer floods are rare, having resulted in the flooding of the Red River only three times during the 36 year record of the Grand Forks gaging station previous to 1918. 1916 was the last flood of the Red River up to the spring of 1943 when a damaging flood stage of 34 feet was reached. All of the eight highest floods were in the early spring, and, furthermore, in only seven of the thirty-six years was the water at a higher stage in summer than in early spring.

Temperatures of the basin are markedly continental with cold winters subject to extreme cold spells and blizzards and warm summers with terrific hot spells due largely to hot southwest winds. This continentality of climate, together with the open north-south valley of the Red River, and the absolute absence of any barrier to either the north or south winds, are causes of these temperature extremes. Other major causes are the relative position of high and low pressure areas and the location of the cyclonic storm tracks (Figure 9).

Pembina at the northern border of the basin has a January average of minus 2.4 degrees F. while Moorhead in the south central section has a January average of plus 3.8 degrees F. These stations have a July average of 67.5 degrees F. and 67.9 degrees F. respectively, and corresponding ranges of 69.4 and 64.1 degrees F. Outside of the higher elevations elsewhere in the United States, the Red River Basin is the coldest spot in the Nation in the winter months.

The so-called valley of the Red River

FIGURE 5.—Irregular and forested morainic upland on the Minnesota side of the Red River Basin.

itself is about 35 to 40 miles wide terminating on either side in the low beach ridges of glacial Lake Agassiz which, in turn are backed by moraines somewhat more elevated. This wide and open valley is exposed alike to the cold winds of the north or the heat of the south winds and, with but little moderation in either. The hot wind which gave Moorhead, Minnesota, in the southern part of the valley 114 degrees F. on July 6, 1936 reached Pembina in the northern part of the valley on July 7 with a maximum reading of 109 degrees F. Reversing this, the cold spell of January 22, 1936 gave Pembina a reading of minus 41 degrees F. and Moorhead, minus 37 degrees F. on the same date.

Extreme temperatures such as 114 degrees F. July 6, 1936 and minus 37 degrees F. January 22 of the same year at Moorhead, Minnesota; 118 degrees F. July 6, 1936, and minus 47 degrees F. on February 15 of the same year at Cooperstown, North Dakota have been recorded by the United States Weather Bureau. Close approximations of these figures are the rule and may be expected each year. The difficulties of protecting and using water supplies under such extremes can only be appreciated by those who have to contend with them.

FIGURE 6.—Battle Lake, part of the Otter Tail River System.

FIGURE 7.—Buffalo River rapids descending to the plains from the morainic uplands in eastern Clay County, Minnesota.

In addition to these extreme changes comes the rapid changes of weather also with the passage of the cyclonic storms. These changes often occur with such rapidity that tremendous property damage and loss of life result. On November 11, 1940 a raging blizzard swept over the northwest with wind velocities from 50 to 70 miles per hour. Within a few hours the temperature fell from 28 degrees F. to 9 degrees F. The swirling snow was blinding and the visibility zero. Traffic of all kinds was halted and many automobiles ditched or stalled on the highways. Duck hunters who were taking advantage of the vacation were unable to find their way to safety. Scores of people were frozen—112 people in Minnesota alone. Thousands of animals, particularly turkeys, unprotected because of the previously mild weather were frozen or buried under the heavily drifting snow. Weather conditions such as these place a premium on resourcefulness and preparedness.

Another recent illustration of the rapidity of extreme weather changes occurred on Saturday, March 15, 1941. The weather was warm and thawing all day of March 15. There was only a slight southerly breeze. The pressure sank rapidly during the day and by 9 p.m. had reached 28.44 on the Moor-

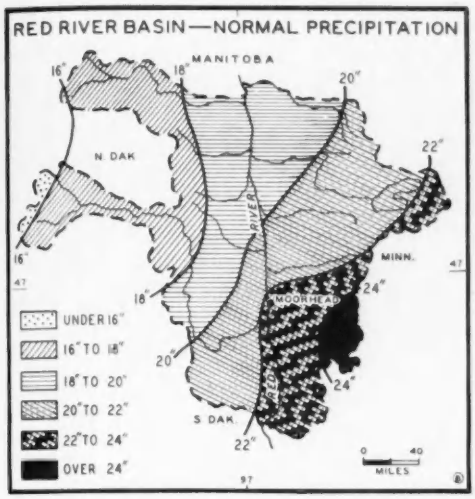


FIGURE 8.—Normal precipitation in the Red River Basin.

head, Minnesota State Teachers College barograph (Figure 10). Suddenly, the wind shifted to the northwest about 9.15 p.m. and within a few minutes had reached a velocity of 50 miles an hour on the college anemometer. At 9.30 p.m. the anemometer showed a velocity of 65 miles an hour. The college thermometer at that time showed a temperature of 26 degrees F. above zero. By 10.05 p.m. the United States Weather Bureau was reporting velocities for a minute duration of 74 miles per hour and the temperature had plummeted to 6 above zero. Blinding snow accompanied the blast making visibility impossible. It was impossible for anyone to venture out of doors with safety and police ordered all theatres, dance halls, and other places where people had congregated to retain their patrons for the duration of the storm. Seventy-three people in the Red River Valley who were caught in the storm were frozen to death. By the morning of March 16 the blizzard had abated considerably but the temperature was 5 degrees F. below zero. By noon the storm had almost completely subsided. Some impression of the hazards of venturing out into storms of this nature can be had from Figure 11.

The plant cover of the basin was formerly prairie with the exception of its eastern border. The southern part of the eastern border was in the Minnesota hard wood belt and was called the "Big Woods." Excepting for swampland the northern half of the eastern border was coniferous and to a large extent is still second growth coniferous and aspen. Quite extensive woodlots of scrub oak are still found in the southern hardwood section. The prairie is now almost entirely in cropland. By 1930, 77 per cent of the basin area was reported in farms and 92 per cent of this was listed as improved for cropping.

Some effects of these cover changes on the water supply follows: Simpson writes that forest cover is the most beneficial for water storage, "Timberlands act as reservoirs of rainfall, gradually feeding it into the ground, and thus not only equalize but increase the ground water supply and cause the ground-water surface to stand relatively high. The prairie grasses, on the other hand, form with their rootlets a thick matted sod, which is to a large degree impervious to water, thus preventing much of it from soaking in and increasing the run-off from the heavy showers. This sod holds the water from light rainfalls on the surface, where it is quickly evaporated. The prairie is thus a region of rapid run-off and little absorption and therefore of relatively low ground water level. The sod does, however, tend to conserve the water that enters the ground by restricting evaporation from the soil." Simpson continues that cultivation further lowers the water table and depletes ground reserves by increasing evaporation from the soil.

Ground water, formerly subject to

only the most incidental use of the aboriginal occupant of the basin, has become the mainstay of the present farmer and villager. The uniform and widespread occupance of the Red River Basin is the result of a like uniform and widespread supply of ground water. Fertile plains, remote from the surface water of the few streams, have become the locality of farmstead or village on the basis of wells.

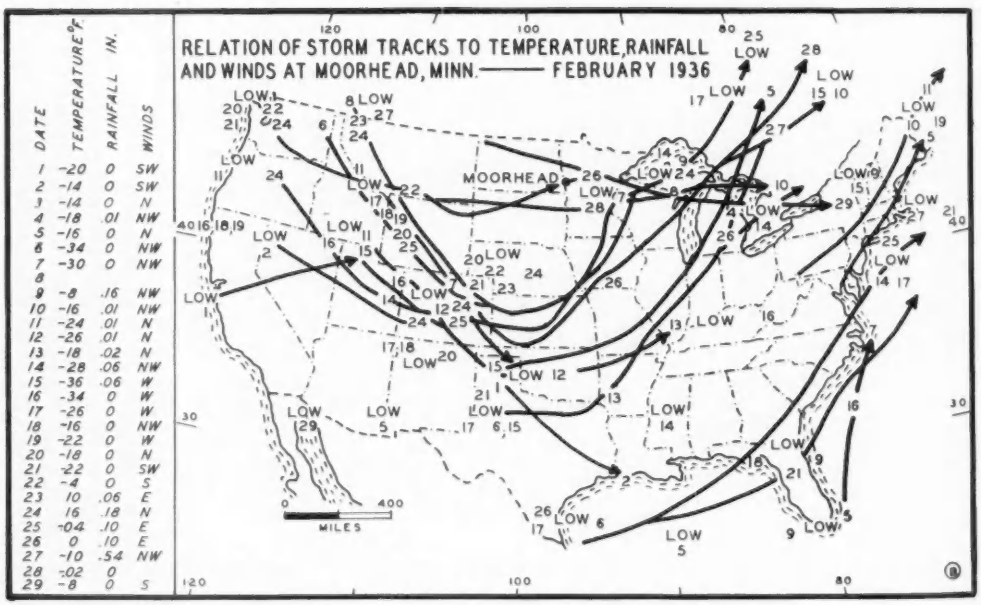
The rivers, though small, have played an important part in the early development of the basin and serve mainly now to supply the larger cities with water in lieu of an insufficient concentration of ground water for such large city supply.

The basin is fortunate in the natural provision of a large store of ground water through the immense mantle of glacial drift over the entire drainage area. No natural or artificial substitute could replace this effective storage of the moderate rainfall of the basin or yield it to use so readily and with such purity.

Although lakes are numerous in the eastern part of the basin, they do not play a major role in the present direct use of potable water but are very important in stabilizing the supply of both stream and ground water.

Climate enters into every phase of supply and use. Rainfall replenishes the depleted supplies of water used by the inhabitants of the valley. The heat of summer diminishes through evaporation the accumulation of water supply reserves and increases the consumption of water by both man and beast. The cold of winter requires numerous provisions to keep the water from freezing and to maintain adequate supplies when all surface waters are frozen deeply and when the only precipitation is in the form of ice or snow. Wind becomes a power to lift the deeper ground waters to the surface for the small user of water, namely the farmstead.

The most comprehensive early survey of water supply and supply problems was made by P. T. Simons, and Forest



DATE	TEMPERATURE °F.	RAINFALL IN.	WINDS
1	-20	0	SW
2	-14	0	SW
3	-14	0	N
4	-18	.01	NW
5	-16	0	N
6	-34	0	NW
7	-30	0	NW
8			
9	-8	.16	NW
10	-16	.01	NW
11	-24	.01	N
12	-26	.01	N
13	-18	.02	N
14	-28	.06	NW
15	-36	.06	W
16	-34	0	W
17	-26	0	W
18	-16	0	NW
19	-22	0	W
20	-18	0	N
21	-22	0	SW
22	-4	0	S
23	10	.06	E
24	16	.18	N
25	-04	.10	E
26	0	.10	E
27	-10	.54	NW
28	-02	0	
29	-8	0	S

FIGURE 9.—Showing storm tracks for February, 1936.

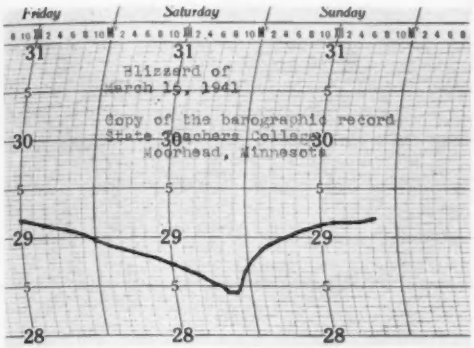


FIGURE 10.—Copy of the barographic record of the blizzard of March 15, 1941, State Teachers College, Moorhead, Minnesota.

V. King and was published in 1922, entitled: *Report on Drainage and Prevention of Overflow in the Valley of the Red River of the North.* This report describes the general water supply conditions of the basin but consists mainly of detailed charts showing river flow data in flood stages and also drainage data.

On the North Dakota side Dr. Howard E. Simpson of the University of North Dakota has made a thorough survey of the ground water resources and it was published as Water Supply Paper 598 in 1929. This paper has been referred to frequently in the present discussion of the ground water conditions of the basin. Mr. Simpson also included a survey of water supply and consumption for the organized systems of North Dakota. An entire basin survey was made for the first time by the National Resources Committee and published in August, 1937 as *Regional Planning Part V Red River of the North.* This report contains a general account of the occupation and industry of the basin outlining and defining the culture of the basin as well as the water supply. The report covers the surface water with considerable detail but neglects the ground water and consumption of water. The present survey is indebted to this National Resources Committee's report as one source for its base map of the basin, for the basin population from 1890–1930, and for numerous minor references and maps. Many small scattered reports of various phases of water supply and use have been published by various authors. Dean Elwyn F. Chandler, professor emeritus of the college of engineering of the University of North Dakota, is the leading publisher of such minor reports, followed by the North Dakota State Planning Board of Bismarck, North Dakota; the Department of Drainage and Waters, State of Minnesota, St. Paul; the Tri-State Waters Commission, Walter Olson, Executive Secretary, State Capitol, St. Paul, Minnesota; and the Minnesota Department of Conservation, St. Paul.

This present survey and report is more extensive and covers all sources of water supply in the Basin of the Red River of the North and relates these sources of supply to consumption in organized systems, organized villages, and farmsteads. This paper also considers in more detail some of the factors which affect the supply and consumption of water.

FARM WATER SUPPLY

Farming is the basic economy of the Basin of the Red River of the North.

FIGURE 11.—This scene was taken on January 14, 1941 about 2 p.m. Snow was blowing lowering visibility and extending drifts across the highway. The telephone poles served as highway markers.

There is practically no occupation in the basin that is not directly dependent upon, or closely allied to farming. In turn, this farm economy with its present diversification and dependence upon animal enterprises is equally dependent upon an abundance of good quality water. For the farms this quantity and quality of water is supplied almost entirely through wells. The fact that well water can be secured at almost any place in the basin has been an important factor in locating farmsteads most effectively for farm economy and without reference to surface water supply. To portray all of the relationships between farms and water supply for the entire basin is beyond the scope of this survey. Nevertheless, an attempt is made to give some idea of the more intimate interrelations existing between the basin farmer and his water supply and use of water in the following survey of Clay County.

Physical Geography of Clay County

Clay County is located in the approximate center of the southern half of the Red River Basin with its entire western boundary formed by the Red River. It is a compact nearly square area thirty-six miles north and south by thirty miles east and west. Its northern, eastern, and southern borders are the artificial parallels and meridians of the land survey. Its area is 1,043 square miles or 667,520 acres. There are thirty townships in the county all having about the mathematical equivalent of the congressional township and being uniformly bounded by the mathematical lines of the land survey. The cultural pattern is therefore quite uniform following the geometric design of the land survey rather than the slight contour of the land surface.

The surface of the county falls readily into three well defined belts aligned north and south (Figure 12). Covering about half of the County from the river to the 950 foot contour is the glacial Lake Agassiz plain. This plain is flat and featureless except for its striking flatness and freedom from surface impediments in the form of boulders (Figure 13). The Buffalo and Red River systems form the only natural drainage excepting for the northeast corner which is drained by the Wild Rice River. These rivers have trenched the plain only slightly and are imperceptible even at close range except for the trees which line their banks. For the most part this plain is well drained with the aid of ditches. Marshes and poorly drained areas now appear only at the base of the beach ridges just east of the 950 foot contour.

The next belt is the glacial Lake Agassiz beach ridges with the Campbell, Norcross, and Herman beaches being particularly well defined (Figure 12). These beach ridges rise abruptly from the floor of the lake bed from about the 950 foot contour to the 1,150 foot contour. The beaches are roughly parallel in alignment and the rise from the lake plain is uniform and terrace-like. With the slope and sandy nature of the beaches drainage is good and much of the area is droughty. At Muskoda the Buffalo River, in its descent from the uplands, has cut quite a ravine in this loose material, particularly in its former delta. The water flows rapidly and there are frequent stretches of rapids which is in marked contrast with its sluggish flow over the plain.

The third belt is the upland of Clay County or morainic belt. Except for the valley of the Buffalo River this morainic upland is made up of the Bigstone moraine as defined by Leverett. The land is comparatively high above the lake plain being 1,515 feet

above sea level at one point or nearly 600 feet above the lake plain. The surface is very uneven with a medley of hills and basins in picturesque contrast with the uniform beach ridges or flat lake plain. Regardless of its elevation the morainic upland is not well drained. Individual hills and slopes may be well drained but there is no drainage system and the water collects in the basins as lakes, sloughs and swamps. There is some surface litter of boulders but for the most part the farmers have been able to gather these stones in piles and cultivate the land. Pasture occupies the fields too stony for clearing and cultivation (Figure 14).

The soils change with the surface to a marked degree. The Fargo and Bearden silt and clay loams are the heavier soils and occupy the lake plain almost entirely. There is the exception of the narrow belt extending southward from Glyndon Township through Elmwood and Alliance Townships. This belt may be the top of the Erskine

FIGURE 12.—Natural Regions of Clay County.

FIGURE 13.—The Moorhead State Teachers College (1934) and the cultivated fields of Glacial Lake Agassiz Plain. The smooth plain permits geometric design for both farmers and landscape artist.

moraine which is obscured and all but buried by the lake silts. In this strip the soils are the same as in the beach ridges. There is hardly any exception to the complete cultivation of these fertile soils of the lake plain.

The Sioux loamy sand and the Ulen loamy sand with the undifferentiated soils of the Tanberg make up the beach belt soils. With the exception of the Tanberg, these light soils appear on the lake plain at the base of the beach ridges as fine sand and become coarser of texture as the beaches are reached. These soils are light, droughty, and infertile and except for hay and pasture are mostly unused. Blowing and drifting of the soil here is common. The Tanberg is the soil of the marshes.

The soils of the Barnes group in the morainic upland vary from loams and sandy loams to silt and stony loams. For the most part they are heavier than the beach soils and make excellent crop land for cultivation when free of stones. The morainic section of Clay County is quite as well occupied by farms as the more easily farmed lake plain.

The only climatic difference in the county is the increase in rainfall to

the east. The upland has about a two-inch higher annual average in precipitation.

Except for the streams and farmsteads there are no woodlands or trees and prairie grasses are the natural vegetative cover of the county. These grasses vary only with the soil and drainage. Shrubs such as the wild plum and choke cherry are common to the beach ridges.

The history of the peopling of Clay County is the same as the history of the peopling of the basin. Settlement began about 1871. That same year the Northern Pacific's first train reached Moorhead on December 12, 1871. Development with railway access to the outside world was rapid and by April 14, 1872, Clay County was organized. In 1890 the population had reached 11,517. The population gained steadily being by decades—1900, 17,942; 1910, 19,640; 1920, 21,780; 1930, 23,120; and in 1940, 25,337.

The city of Moorhead, the only town of urban rank in the county likewise grew rapidly and by 1940 had a population of 9,491 or 37 per cent of the county's total population. The rural population was therefore 15,846 or about 63 per cent of the total population of the county. The population outside the village corporations is fairly uniformly distributed over the county. It is remarkable, however, that the rural population in the eastern upland townships is the largest in the county. The population in corporations in 1940 was 15,103 or about 60 per cent, while the unincorporated villages and farm population was 10,234 or about 40 per cent. The number of farms in 1940 was given as 2,128.

The distribution of farms in the county as shown by the map of farms (Figure 15) is fairly uniform with some variation with each belt. The area of beaches has markedly the fewest farms while rather unexpectedly the upland townships along the eastern border are most thickly occupied. The lake plain

FIGURE 14.—Landscape in the Morainic Upland of eastern Clay County. A shows a pile of boulders cleared from a cultivated field. B shows a stony pasture. C shows a lake. D shows the rolling surface with some woodlots.

shows an even spread with some evidence of concentration along the Red and Buffalo Rivers.

A perusal of the date in Table II on selected comparative agricultural data for Clay County reveals some facts that have relation to water consumption in the county. The farm animal population of the county in 1940 is about triple the human population and this places the livestock water supply burden largely on the farmstead well supply as very little surface water is used in Clay County for livestock.

Another fact brought out by Table II is that the demand for farmstead water supply has increased since 1920. Clay County has 180 more farms in 1940 than in 1920 and therefore, a greater number of farm water supply setups. In addition to the increase in the number of farms it appears safe to say that there has been no decrease at least in the need for water for livestock. Horses have decreased to about half of the 1920 population but cattle have increased by about the same number as the decline in number of horses. Considering the needs of cattle and dairy products for water, it is safe to say that the increase in cattle more than maintained the livestock demand for water.

Among these crops (Table II) the demand for water other than soil moisture is coming from the irrigation of alfalfa and sugar beets. Neither acreage is large as yet. Alfalfa shows a small increase in the past decade while the acreage of sugar beets increased very markedly over the beginning of 1930.

Clay County Farm Water Supply and Use

With the assistance of Mr. Donald Peet, Clay County Agricultural Agent,

TABLE II

AGRICULTURAL STATISTICS FOR CLAY COUNTY WITH COMPARATIVE DATA

Item	*1920*	*1930*	*1940*
Area of County	667,520A.	.....	.....
Number of farms	1,948	2,089	2,128
Land in farm	580,717	569,592	611,082
Average size of farm	298.1	272.9	287.2
Crop land harvested	.....	364,194	399,948
Pasture	.....	90,530	.....
Woodland	.....	18,777	18,777
Tenure—Full owners	1,254	1,200	1,184
Tenants	678	873	940
Farms over 500 acres	.....	144	189
Farms over 1,000 acres	.....	17	30
Horses	16,190	13,424	8,967
Cattle	29,579	28,517	37,000
Swine	8,296	8,105	13,500
Chickens	142,250	139,555	.....
Sheep	.....	.....	12,000
Corn (acres)	704	23,430	39,983
Corn for grain (acres)	.....	1,433	.....
Wheat (acres)	65,134	33,631	82,630
(91 acres Winter Wheat—in 1940)			
Oats (acres)	96,200	154,039	74,659
Barley (acres)	46,922	66,501	58,462
Rye (acres)	9,022	24,622	5,341
Flax	17,998	5,798	28,412
(Buck-wheat 228 acres in 1940)			
Hay (acres)	77,201	77,865	74,579
Alfalfa (acres)	.....	9,538	10,242
Potatoes (acres)	31,652	45,577	28,412
Sugar beets (acres)	.....	605	2,579

(1) Data from the Fifteenth and Sixteenth Census of the U. S. and Minnesota State Farm Census, 1940.

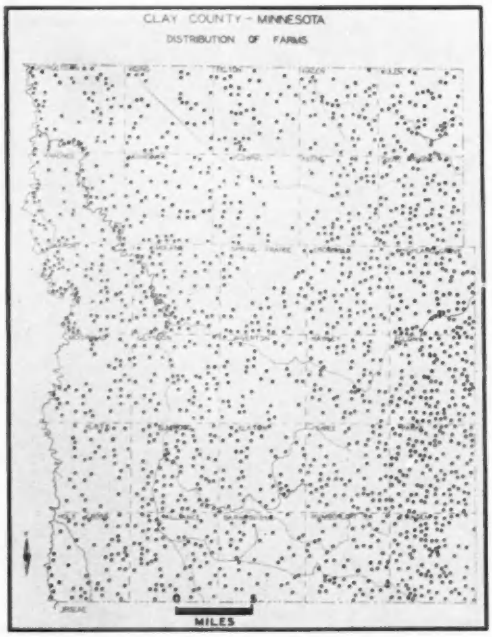


FIGURE 15.—Distribution of farms in Clay County by Township and Section.

water supply and use questionnaires were sent to all Clay County farmers—2,128 in number. The questionnaire form used is shown at bottom of page. Due to the help given by Mr. Peet a very generous response of 1,610 replies were received providing an ample sampling and a very adequate geographic distribution.

Table III shows the number of replies by township and Figure 16 is a map representing this township distribution of replies. Hagen township was far below all other townships in replies returned—being just under 25 per cent of the number of farms.

The data for the replies on well depth was averaged and these averages shown on map in Figure 17 distributed by townships. Also a map showing the maximum and minimum well depth for each township was made (Figure 18). On these maps there is an obvious relationship between the three natural belts in Clay County. The wells average consistently deep in the lake plain, consistently shallower in the beach ridge area, and then, consistently deeper again in the morainic upland. It is significant that both Keene and Hagen Townships show the shallowest wells thus revealing the effect of the beach ridges which are widespread in these townships. The ground water of the porous morainic uplands and from the equally porous beach ridges readily comes toward the surface in this belt and is under greater hydrostatic pressure.

That this is true is readily shown by the map of flowing wells, which in addition to these shallow wells in the beach ridges, show practically all of the flowing wells occurring here also (Figure 19).

We are making a survey of some rural supply problems. Will you please help by checking the blanks on the form below and return to us?

1. Check your source of supply: Well....., Cistern....., Spring....., Lake.....,
   Pond or Slough....., or Pit....., snow or ice.....
2. How deep is the well?..... Does it reach bedrock?.....
3. For pumping water do you have—Windmill....., Engine....., Hand pump.....
4. For keeping water from freezing for livestock in winter do you have barn tank or cups.....
   Tank heater.....?
5. For heating tank do you use—Oil....., Coal....., or Wood.....?
6. Do you have enough water? Yes....., No.....
7. What is your township....., Section.....

TABLE III

SUMMARY OF WATER SUPPLY SURVEY FOR FARMS OF CLAY COUNTY, MINNESOTA—BY QUESTIONNAIRE

Township	*Replies*	*Av. Well Depth in Ft.*	*Water Supply (well, cistern, lake, river, slough, pit, ice and snow, flowing well or spring)* *	*Windmills, Engines, Pumps* **	*Enough Water*	*Tanks Including Barn Tanks and Cups*	*Tank Heaters*	*Coal, Oil, Wood*
Alliance	38	127	w 24	w 13	yes 22	28	4	c 2
	..	...	c 7	e 11	no 3	..	..	o 1
	..	...	fl 2	p 6	.....	..	..	w 1
Barnesville	40	105	w 21	w 2	yes 18	15	4	c 2
	..	...	c 2	e 7	no 2	..	..	w 2
	..	...	fl 4	p 12				
Cromwell	69	92	w 62	w 27	yes 38	21	5	o 5
	..	...	c 15	e 23	no 1			
	..	...	fl 2	p 4				
	..	...	s 13					
	..	...	i 1					
Eglon	69	155	w 55	w 29	yes 53	38	17	c 1
	..	...	c 27	e 24	no 4	..	..	o 1
	..	...	fl 1	p 3	.....	..	..	w 15
	..	...	L 3					
	..	...	s 1					
Elkton	62	86	w 44	w 12	yes 38	15	15	c 4
	..	...	c 17	e 11	no 3	..	..	o 3
	..	...	fl 4	p 22	.....	..	..	w 8
	..	...	L 1					
	..	...	s 3					
	..	...	p 3					
Elmwood	46	119	w 44	w 14	yes 26	25	7	c 1
	..	...	c 3	e 19	no 6	..	..	o 1
	..	...	s 1	p 12	.....	..	..	w 5
	..	...	i 1					
	..	...	p 1					
Felton	79	133	w 35	w 3	yes 38	19	1	w 1
	..	...	c 10	e 3	no 2			
	..	...	fl 10	p 21				
Flowing	37	108	w 27	w 1	yes 26	12	2	c 1
	..	...	c 6	e 1	.....	..	..	o 1
	..	...	fl 11	p 4				
Georgetown	87	191	w 52	w 4	yes 52	36	18	w 12
	..	...	c 24	e 17	no 4	..	..	o 6
	..	...	fl 3	p 16				
	..	...	r 1					
Glyndon	64	130	w 53	w 18	yes 45	19	6	w 5
	..	...	c 14	e 18	no 4	..	..	o 1
	..	...	fl 4	p 18				
	..	...	r 1					
	..	...	s 1					
	..	...	p 3					
Goose Prairie	80	93	w 64	w 35	yes 66	38	11	w 9
	..	...	c 17	e 32	no 1	..	..	o 2
	..	...	s 5	p 36				
	..	...	p 1					
	..	...	fl 2					
Hagen	12	28	w 9	e 2	yes 9	5	1	w 1
	..	...	r 2	p 6				
	..	...	p 1					
	..	...	fl 2					

*In this column the letters have the following meaning: w, well; c, cistern; L, lake; r, river; s, slough; p, pit; i, ice or snow; fl, flowing well or spring.

**In this column the letters have the following meaning: w, windmill; e, engine; p, pump.

TABLE III

SUMMARY OF WATER SUPPLY SURVEY FOR FARMS OF CLAY COUNTY, MINNESOTA—BY QUESTIONNAIRE—*Continued*

Township	*Replies*	*Av. Well Depth in Ft.*	*Water Supply (well, cistern, lake, river, slough, pit, ice and snow, flowing well or spring)* *	*Windmills, Engines, Pumps* **	*Enough Water*	*Tanks Including Barn Tanks and Cups*	*Tank Heaters*	*Coal, Oil, Wood*
Hawley	50	83	w 35	w 12	yes 18	22	6	c 1
	..	...	c 12	e 21	no 3	..	..	o 2
	..	...	r 1	p 7	.....	..	..	w 3
	..	...	s 1					
	..	...	p 2					
	..	...	i 3					
	..	...	fl 2					
Highland Grove	69	122	w 53	w 31	yes 5	30	19	c 1
	..	...	c 18	e 14	.....	..	..	o 3
	..	...	fl 2	p 6	.....	..	..	w 15
Holy Cross	76	116	w 61	w 22	yes 55	29	11	c 1
	..	...	c 14	e 27	no 3	..	..	o 5
	..	...	s 1	p 20	.....	..	..	w 5
	..	...	r 1					
Humboldt	52	76	w 32	w 8	yes 34	15	7	o 2
	..	...	c 9	e 13	.....	..	..	w 5
	..	...	s 8	p 8				
	..	...	p 7					
	..	...	i 2					
	..	...	fl 9					
Keene	32	47	w 28	w 4	yes 21	9	2	w 2
	..	...	c 9	e 17	no 4			
	..	...	L 1	p 4				
	..	...	s 3					
	..	...	fl 3					
Kragnes	70	173	w 56	w 19	yes 42	31	21	o 6
	..	...	c 11	e 19	no 1	..	..	w 15
	..	...	i 1	p 10				
Kurtz	33	134	w 26	w 10	yes 22	13	11	c 4
	..	...	p 2	e 13	no 4	..	..	o 4
	..	...	r 1	p 3	.....	..	..	w 3
Moland	47	145	w 40	w 14	yes 30	22	11	c 1
	..	...	c 2	e 12	no 5	..	..	o 6
	..	...	.....	p 10	.....	..	..	w 4
Moorhead	53	173	w 39	w 25	yes 32	30	16	c 5
	..	...	r 1	e 9	no 5	..	..	o 8
	..	...	.....	p 4	.....	..	..	w 3
Morken	57	144	w 45	w 12	yes 35	28	23	c 4
	..	...	c 4	e 10	no 2	..	..	o 10
	..	...	i 1	p 10	.....	..	..	w 9
	..	...	fl 2					
Oakport	48	159	w 38	w 22	yes 30	20	13	o 2
	..	...	c 3	e 14	no 1	..	..	w 11
	..	...	.....	p 3				
Parke	53	93	w 44	w 4	yes 41	12	17	o 1
	..	...	c 25	e 26	no 1	..	..	w 16
	..	...	L 4	p 8				
	..	...	fl 8					
Riverton	25	85	w 21	w 2	yes 22	13	1	w 1
	..	...	c 3	e 3	no 2			
	..	...	fl 10	p 5				

*In this column the letters have the following meaning: w, well; c, cistern; L, lake; r, river; s, slough; p, pit; i, ice or snow; fl, flowing well or spring.

**In this column the letters have the following meaning: w, windmill; e, engine; p, pump.

TABLE III

SUMMARY OF WATER SUPPLY SURVEY FOR FARMS OF CLAY COUNTY, MINNESOTA—BY QUESTIONNAIRE—*Continued*

Township	*Replies*	*Av. Well Depth in Ft.*	*Water Supply (well, cistern, lake, river, slough, pit, ice and snow, flowing well or spring)* *	*Windmills, Engines, Pumps* **	*Enough Water*	*Tanks Including Barn Tank and Cups*	*Tank Heaters*	*Coal, Oil, Wood*
Skree	35	69	w 25	w 10	yes 23	13	5	o 1
	..	...	c 5	e 8	no 1	..	..	c 1
	..	...	s 2	p 12	.....	..	..	w 3
	..	...	p 8					
	..	...	fl 5					
Spring Prairie	36	102	w 28	w 1	yes 24	4	o	o
	..	...	c 4	e 1				
	..	...	s 1	p 3				
	..	...	fl 14					
Tansem	81	94	w 68	w 20	yes 57	53	35	o 2
	..	...	c 18	e 41	no 2	..	..	w 33
	..	...	L 6	p 16				
	..	...	s 37					
	..	...	p 8					
	..	...	i 19					
	..	...	fl 6					
Ulen	74	59	w 58	w 6	yes 62	10	4	w 4
	..	...	c 21	e 29	no 1			
	..	...	r 4	p 26				
	..	...	s 3					
	..	...	fl 4					
Viding	36	176	w 26	w 15	yes 21	13	9	o 2
	..	...	c 9	e 5	no 1	..	..	w 7
	..	...	.....	p 11				
Totals	1,610	...	w 1,213	w 395	yes 1,005	638	302	
	..	...	c 309	e 450	no 66			
	..	...	L 15	p 326				
	..	...	r 12					
	..	...	s 80					
	..	...	p 36					
	..	...	i 28					
	..	...	fl 107					

*In this column the letters have the following meaning: w, well; c, cistern; L, lake; r, river; s, slough; p, pit; i, ice or snow; fl, flowing well or spring.

**In this column the letters have the following meaning: w, windmill; e, engine; p, pump.

The minimum depth of the lake plain wells shows that there is no likely exception to the dependence upon the glacial till for water supply in this area. All minimum well depths are deeper than the Lacustrine Silts with possible exception of the well of 20 feet in Oakport Township.

The wide spread in well depth in the morainic upland is undoubtedly due to some wells being in basins or depressions with a high water table while other wells would be on hills or knolls with a low water table.

It is rather difficult to draw any conclusions on the situation respecting bedrock. The writer in a traverse across Clay County, due east west from Eglon Township to Moorhead Township, found not a single report of bedrock. Yet 210 farmers out of 1,610, report that their wells reach bedrock. If this is really the situation, then the bedrock surface is highly uneven. Georgetown township with a maximum well depth of 300 feet shows no bedrock. Alliance also with a maximum well depth of 196 feet shows no

bedrock. On the other hand, Moorhead township reports 17 wells reaching bedrock—with a maximum well depth reported at 300 feet. However, bedrock is shown in deep test well at Moorhead to be at 475 feet with the glacial till itself reaching a depth of 370 feet.

For about 225 well logs reported in the Casselton-Fargo Quadrangle only one is listed as reaching bedrock and five others as reaching rock. Several report stones which are boulders in the glacial till and are usually blasted out of the way in drilling.

It is consistent, however, that four of the beach ridge townships report no bedrock in this region of shallower wells and likely deeper drift and alluvial deposits. Again the conclusion is obvious and safe that glacial deposits with the fluvial surficial deposits are deep over the entire area and form the basis for the entire water supply.

The response to the question as to the source of water supply was nearly complete. Wells form almost the entire water supply with 1,320 wells listed—107 were stated to be either flowing wells or springs. The wells follow the distribution of farmsteads with the beach ridges showing fewest (Figure 20). That farms avoid the beach ridges for reasons other than water supply is indicated by the abundance of flowing wells along the beach ridges (Figure 19). Flowing wells are shown on this map to be almost exclusively located between the upland and lake plain with concentration most evident in that part of the lake plain immediately at the base of the beach ridges where hydrostatic pressure is greatest. Two astonishing relationships are brought clearly to the front by this well map. The first is the almost total dependence of the agricultural economy of Clay County on well water. The other is that because of the extensive availability of well water over the area the farmers are free to locate to the best economic advantage for farming the land by not being confined or restricted by water supply.

From these relations of the farmers to well water supply comes a conclusion of vital importance. The absence of an alternative water supply makes the maintenance or replenishing of ground water resources a vital natural factor in the economy of the county. Considering the extreme weather which occurs in the county, nothing but the most intimate relation between farmstead and water supply could be practical. A more remote source of water other than well water would not substitute for the convenience of the well water supply even if that more remote source were available. It takes time and money to transport water even under favorable conditions and there are many times when conditions would render hauling extremely inconvenient if not hazardous, to say nothing of the

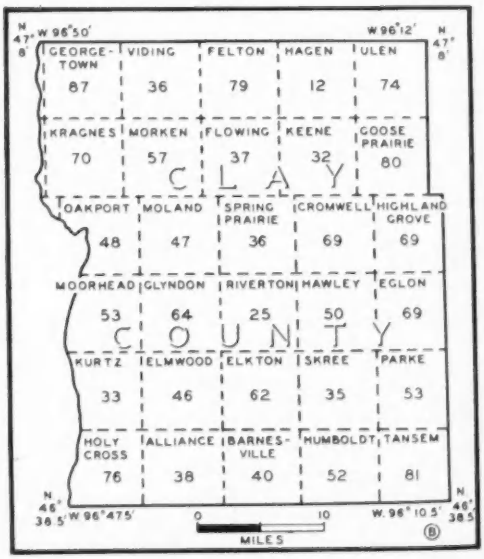


FIGURE 16.—Map showing distribution by townships of replies received on water supply questionnaires from farmers in the Clay County farm water supply survey.

time and money which farmers can ill afford at any time.

It appears little short of foolhardiness to continue the extensive use of such a vital resource without the most continuous and careful record of its fluctuations. The present well level records of the Red River basin, particularly on the Minnesota side are wholly inadequate. From such records of well levels carefully kept, much could be learned of the relation of demand to supply and the agricultural enterprises adjusted to meet the conditions of supply. It may be discovered that irrigation could be more extensively applied in the basin. Or, on the other hand, the discovery that irrigation would seriously deplete ground water levels would lead to the timely restriction of irrigation and the conservation of the ground water for present established agricultural enterprises.

It must be emphasized here again that natural conditions are extremely favorable to the maintenance of ground water supplies in the county and the basin. The great depth of glacial drift, the receptiveness of this drift to water storage, the low gradient permitting rainfall to sink in, the youthful drainage system with innumerable basins for local natural water storage, all provide for maximum retention and storage of the rainfall of the county and basin in ground water reserves. To this end care and thoughtfulness must be exercised in such projects and economies as irrigation, drainage, and clearing and cultivating the land.

The 309 cisterns listed were in every instance a supplementary water supply. These cisterns are located by the farm house and in many instances piped into the house for greater convenience. A hand pump at the kitchen sink in such cases provides very conveniently soft water for washing. Cistern water is largely for soft water for the laundry,

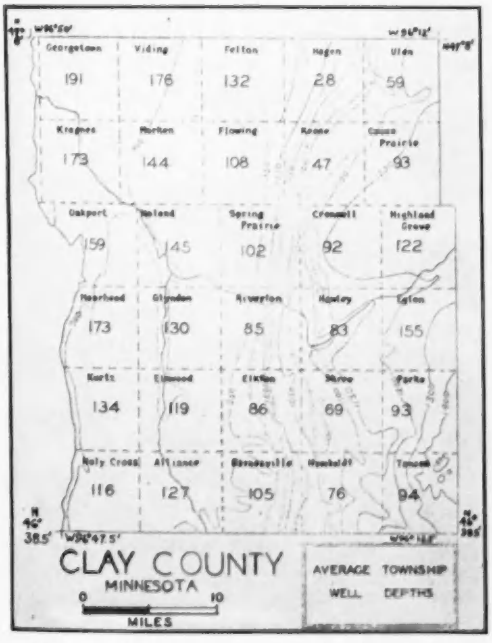


FIGURE 17.—Average well depth by townships of the wells of Clay County farmers.

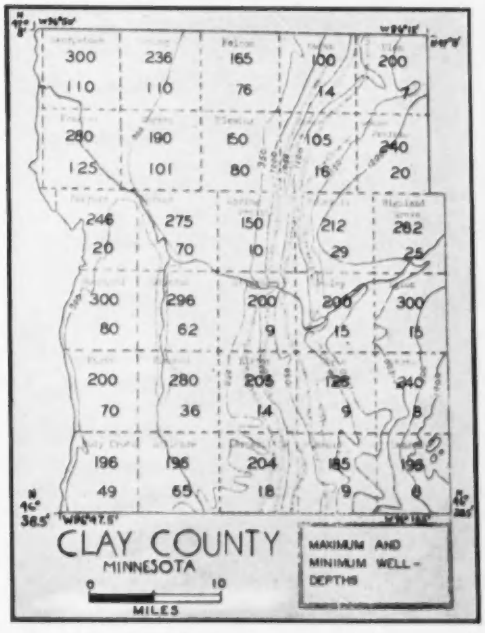


FIGURE 18.—Maximum and minimum well depth by townships of the wells of Clay County farmers.

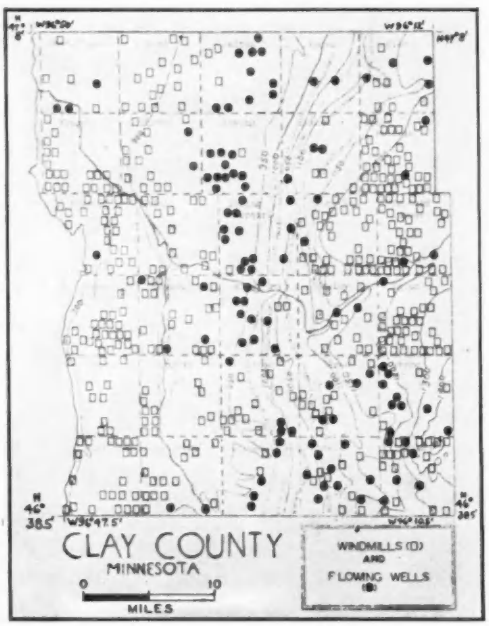


FIGURE 19.—Distribution of windmills and flowing wells by township and section on the farms of Clay County.

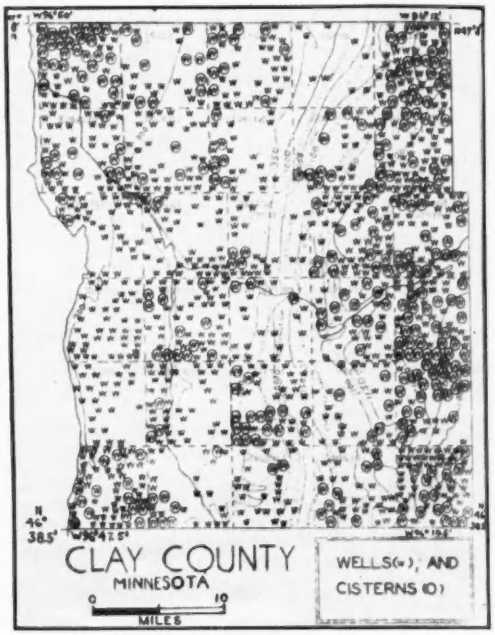


FIGURE 20.—Distribution of wells and cisterns by townships of the wells of the farmers of Clay County.

washing dishes, and like uses where soft water is much more adaptable and economical than the hard well water. Considering the rainfall drought of the long cold winter and the moderate summer rainfall, a cistern water supply can only be considered as very incidental to the county's water supply.

The recourse to other sources of water supply in Clay County is interesting even if very extremely limited (Figure 21). The fifteen lakes and eighty sloughs listed for water supply were practically all in the uneven and poorly drained surface of the upland. It is interesting to observe that even with a large number of farmsteads near the few streams, they do not draw greatly on the rivers for supply—only 12 out of 1,610 reporting the river as a source. The freezing in winter to thick ice on the streams renders them impractical for one thing and for another the water in the streams becomes stagnant in summer and is ill-suited to use. Pits for the collection of surface water are reported frequently used throughout the basin, but for Clay County, appear a very limited means of supply. The melting of ice and snow is also very rare but it outnumbers the river as a source of supply. With an abundance of snow during the long cold winter it is not so difficult to shovel snow into a heated tank and get enough water for livestock supply. This method of supplementing water supply is reported throughout the basin.

At best all of these alternative sources of water supply appear only supplemental or expedient in emergencies and of no significance in supplanting the well water for the Clay County basin farms.

The sixty-six farmers who reported inadequate water supplies for present purposes do not constitute a serious cause for alarm but it would be a wise precaution to investigate each of these cases to learn the history of the water supply. It may be possible that faulty

equipment in old wells is failing to bring the water to the surface, but again it may be a case of failing supply and an indicator of the trend of ground water levels.

The two maps (Figures 19 and 22) showing the use of windmills and tank heaters provide an interesting study in relationships. That wind could be a helpful source of power in the flat or rolling terrain of the Red River Basin was early learned. In 1851 Charles Cavalier on a visit to the Selkirk and other settlements in the Red River Basin counted "Fifteen windmills, all grinding out flour at a lively rate." Instead of becoming outmoded the windmills have increased in number until they now constitute a familiar feature on the horizon. The fact that 395 farmers reported them on their farmstead is suggestive of their present extent and use.

It is fairly certain from field surveys that this number of windmills reported by replies to the questionnaire does not represent all of the windmills in use. An actual field count made by the writer in Moland Township totaled thirty-three windmills whereas only 14 were reported by questionnaire. That this prevalence of windmills on the farm is likely true, not only for Clay County but also for the basin, is strongly suggested by a one hundred mile traverse the writer and his wife made north from Moorhead, Minnesota to Thief River Falls, Minnesota. Of the 368 farmsteads listed adjoining the highway, 187 had windmills or just over 50 per cent.

This high average of a windmill for every other farmstead may not hold for the entire basin, however. The aforementioned traverse was made largely in the flat valley. The map of Clay County reveals that windmills are almost wholly lacking on the beach ridges where flowing wells renders them needless. But on the other hand, the uneven upland shows windmills more numerous than the lake plain and strongly suggests that the windmill is as much related to the lift of water from deep wells as to the prevalence of wind. The Red River Basin has next to the highest average wind velocity for any region east of the immediate Pacific Coast having an average of twelve miles per hour as compared to fourteen for the highest average.

An interesting response to the cold winters and the effect on water supply for livestock is the tank heater for tanks outside of the barn. This is an ingenious sheet iron heater so constructed that it can be placed in the water tank with the body of the heater under water for heating purposes. The door of the heater projects above the water on one side for refueling and draft, while on the other side is the pipe for completing the draft circulation. This arrangement is shown in Figure 25, Plates A, B, C, and D. Again it is interesting to note that the beach ridge belt of flowing wells is almost entirely free of heaters. These wells and springs flow freely the year round, and hence, no artificial heat is necessary to render the water available in the cold winter. As is the case in windmills, tank heaters may be more prevalent on the farms than the report of 302 out of 1,610 farmsteads indicates. The prevalence of the use of wood for fuel as compared to coal and oil is surprising considering that woodlots are not a usual part of the farm land use in Clay County. It may be due to the use of imported wood for heating the house, hence, the most readily available fuel for the tank heater. This imported wood is readily available by truck from the second growth forests on the more

TABLE IV

FARM WATER SYPPLY SUMMARY—TRAVERSE EAST-WEST ACROSS RED RIVER VALLEY FROM EASTERN BOUNDARY OF CLAY COUNTY TO WESTERN BOUNDARY OF CASS COUNTY—ALONG HIGHWAY U. S. 10—ALL FARMS INCLUDED

No. of Farms	*No. of People*	*No. of Windmills*	*No. of Cattle*	*No. of Hogs*	*No. of Sheep*	*No. of Horses*
44	216	17	1,594	1,052	2,227	303
Average	5.5 (for 39 places)		37 (for 43 places)	36.2 (for 29 places)	171.3 (for 13 places)	8.1 (for 37 places)

rugged land in the eastern part of the basin.

During the late summer of 1940 the writer investigated the farm water supply conditions across the Red River Valley from the morainic upland on the east to the morainic upland on the west. The traverse was from the eastern border of Clay County, Minnesota due west to the western border of Cass County, North Dakota, following United States Highway number 10. Each farmer along the way was visited and information was obtained according to Farm Water Supply Survey of Clay-Cass Counties. Sixty-six reports were obtained more or less complete. Forty-four of the reports are summarized in Table IV.

These forty-four farms are shown by Table IV to be occupied by 216 people with an average of 5.5 persons to the farm. Seventeen windmills were listed. The total number of cattle was 1,594 for 43 of the farms with an average of 37 per farm. The hogs totaled 1,052 for 29 farms on which hogs were raised or an average of over 36 for these farms raising hogs. Only 13 farms reported sheep with a total of 2,227 sheep or an average of 171.3 sheep per farm raising sheep. Thirty-seven farms owned horses with a total of 303 horses with an average of 8.1 horse per farm owning horses.

By plotting the actual well depth reported by the farmers a generalized mean depth was plotted and is shown for Clay County in Figure 24 together with an exaggerated surface profile. The well depth is the greater in the morainic uplands and then diminishes as the beach ridges are approached and deepens in the valley proper or lake plain area. This corresponds quite well with the average well depth shown in Figure 17 with the exception of Moorhead Township. That the water accumulated by the moraine is the cause for the abundant supply and shallow wells of the beach ridges is quite evident. A fall of about 400 feet in 15 miles is sufficient gradient for strong hydrostatic pressure. Practically all the farmers contacted had wells as the basic water supply regardless of the depth necessary to drill for the water. This is a strong indication of the lack of other reliable supplies.

The farms were visited in sequence from east to west as shown on the maps (Figures 25 and 26). Farm number one had a well 228 feet deep and a cistern as a supplementary supply. The well water was available for livestock by an outside tank and water was carried to the house for drinking and cooking. In winter the water was pumped to the barn for the livestock. A 600-gallon tank was used for the livestock supply. A slough provided some summer water for livestock. There were five people here, 40 head of cattle, no sheep, and for the present no hogs. Bedrock was not reached in drilling

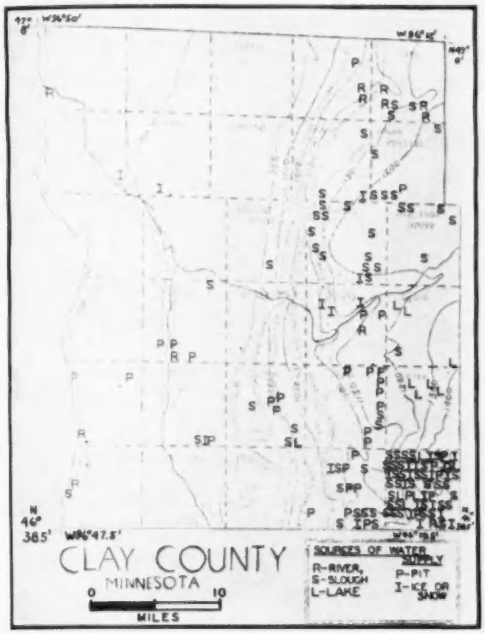


FIGURE 21.—Distribution of other than well water supply for the farmers of Clay County.

the wells. Figure 27, plates A and B show the pump and water tank.

Farm number two had a well 200 feet deep and a cistern in the house. Water was carried to the barn for the livestock in winter. Drinking water was carried to the house. This farm had 20 cattle and five horses. Water supply was steady and abundant and of good quality.

Farm three had a well 170 feet deep with a cistern outside the house. Water was carried to the house. The well has not failed and has been in service since 1908. No bedrock was found in drilling. A windmill was used for pumping the water. The farmer reported only "eight or nine cows."

Farm four had a well 165 feet deep with an outside cistern for supplementary supply. A gas pump was used for power pumping and supplied about 300 gallons a day. The well has yielded steadily for the past 25 years. A tank heater was used to keep the water open in the tank for the livestock. The farm had a herd of 17 cattle. The well does not reach bedrock.

Farm five had a 180 foot well. The livestock was supplied with water from an outside tank kept open in winter by a tank heater. The well did not reach bedrock and has not failed to furnish plenty of water since 1914. There were 18 cattle and five horses on this farm. A summer water supply was available in a slough.

Farm six had both well and cistern with the cistern piped to the house. Well water was carried for drinking. The barn had an inside tank for winter water supply. Water was piped from the well to the barn. A windmill furnished power. There was a slough on this farm. The water was abundant at all times and of good quality. Five people lived here and kept 25 cattle and five horses.

Farm seven supported three people,

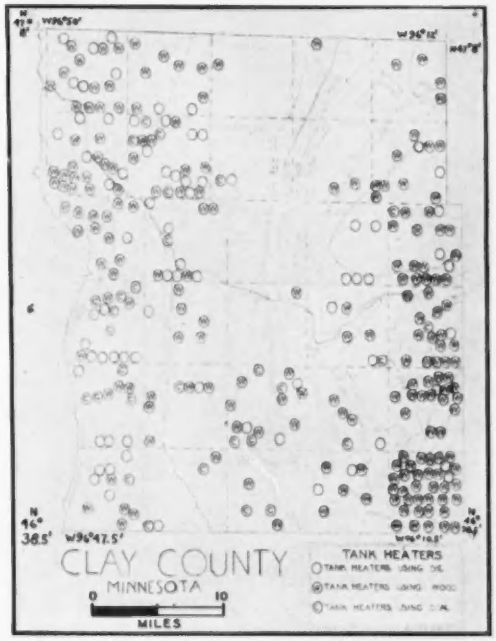


FIGURE 22.—Distribution of farmers using tank heaters to keep their water supply from freezing and at desirable temperatures for livestock consumption.

nine cattle, and five calves. The well was 167 feet deep and had been a constant and adequate supply for 15 years. The house was equipped with an inside pump and cistern. There was an outside water tank for summer and an inside tank for winter water. A tank heater was used to keep water warm in winter for livestock. The well did not reach bedrock.

Farm eight had five people, eleven cows, nine calves, and thirty-five pigs. The well was 160 feet deep but there was no cistern. An outside tank supplied water for livestock supplemented by a slough in summer. A water refrigerator was attached to the well between the well and the tank (Figure 28, plate A). The farmer's young wife was engaged in carrying water to the thirty-five pigs.

Farm nine supported four people, 14 cattle, and five horses. The well was 148 feet deep with a cistern supplementary. An inside barn tank was used for winter livestock supply and was moved outside in summer. The well did not reach bedrock. The water was pumped by gasoline engine.

Farm ten had nine people, 20 cattle, two horses, and 17 hogs. There was no cistern and the well was 90 feet deep. A windmill pumped the water. The tank was kept from freezing by heavy banking in winter. The supply of water was dependable and the water was good. The well did not reach bedrock.

Farm eleven was occupied by two people owning 30 cattle, three horses and 14 hogs. Their well was 232 feet deep and a supplementary supply for stock in summer was a slough. Their water supply was abundant and regular. The house was supplied with water by carrying from the well. A barn tank was used for livestock in winter and a pasture tank in summer. A windmill

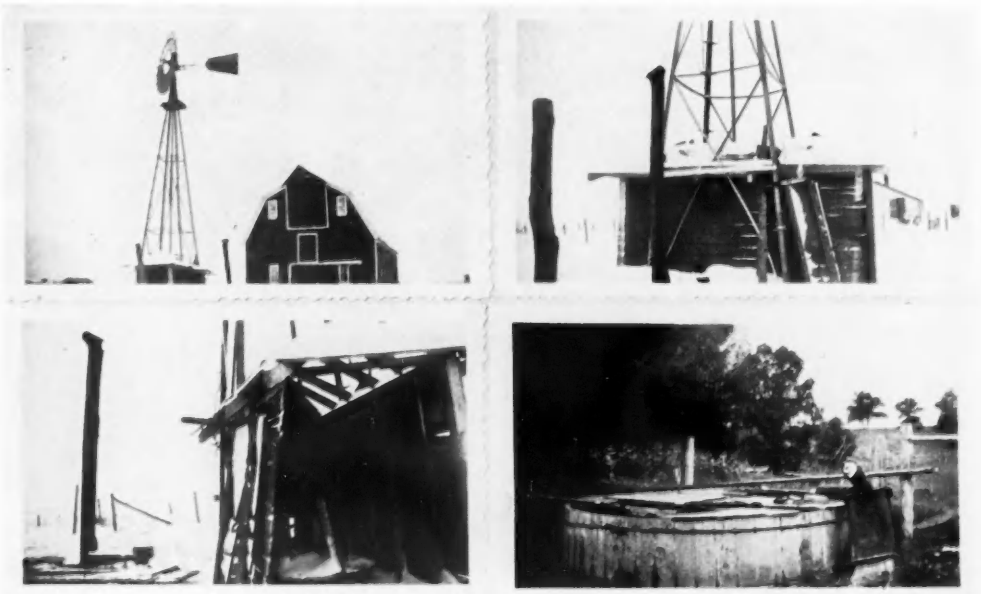


FIGURE 23.—These scenes show at Red River Basin the equipment for keeping water for livestock from freezing in outside tanks in winter. Plate A, upper left, shows the barn and windmill pump. Plate B, upper right shows the pump house, the snow banked tank and the stovepipe of the heater. Plate C is a closer view of the tank top and the heater pipe. Plate D is a tank in summer showing the water heater outside of the tank. The winter scenes were taken in January 1941, just north of Moorhead. Plate D was taken in 1940 in eastern Clay County.

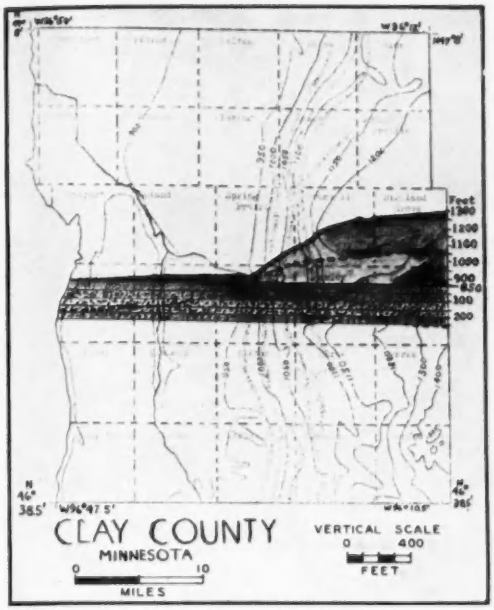


FIGURE 24.—Surface profile and comparative well depth of farmers wells along Highway U. S. No. 10.

pumped the water. A well pit was used in part for refrigeration. The well did not reach bedrock. This farmer, as well as all others of whom inquiry was made, expressed a desire to have drinking cups in the barn for his cows stating that a constant supply increased the milk production and made feeding more economical. None of these farmers had any provision for irrigation and did not practice it.

Farm twelve supported six people, 18 cows, 10 horses, four colts, and eight hogs. They had both well and cistern. The well was 45 feet deep. The well water was reported good and adequate with one exception for the year 1936. The cistern was piped to the house. A tank for watering livestock was outside and the water was kept from freezing by a tank heater—briquets were used for heating. A windmill pumped the water. They used the house basement for refrigeration.

Farm thirteen supported five people, 15 cattle, three horses, and 18 hogs. A hand-dug well 30 feet deep with engine pump supplied the water entirely. The supply was abundant and good. Water was carried to the house. The livestock water tank was outside in summer and inside the barn in winter. Water was carried from the tank in winter to the animals. The well did not reach bedrock.

Farm fourteen had both well and cistern. An outside tank was in use for the livestock. No other information could be obtained. The farmstead was run down and in very poor condition.

Farm fifteen supported five people, four cattle, and four horses. They had a well, cistern, and in addition water was obtainable from a lake, spring, and a stream. Their water supply was stated as abundant and good. They had a cistern pump in the house and a water tank both outside and inside the barn. An engine pumped the water. No well depth was given.

Farm sixteen reported two cattle. (Information from visitor—farm family not at home.) They had both well and cistern. The cistern pump was in the house. Two outside tanks were for the livestock water supply. They had a coal heated tank heater and pumped water by windmill. A water cooler was used for refrigeration.

Farm seventeen supported five people, 145 cattle, nine horses, and nine hogs. Water supply came from well, lake, spring, and stream. There were three wells at 90 feet, 73 feet, and 28 feet. The two shallower wells were flowing wells. This water supply was abundant and good. The house was supplied with water by carrying it from the wells. The livestock was watered by an outside tank and as the water was from flowing wells no additional heat was necessary in winter. Both a windmill and an engine pumped water. The

occupant of the farm was a renter and his opinion was that plenty of water was the most important item in the care of cattle.

Farm eighteen supported six people, 17 cattle, four horses, 80 sheep and eight hogs. The water supply was from a pasture well and another well eighty rods from the house, a lake, a spring, and a stream. The well near the house was 12 feet and the pasture well was 60 feet deep. The well in the pasture (Figure 28, plate B) was described as almost flowing with two neighboring wells at 30 and 50 foot depth, both flowing. Springs were reported as numerous. The water was carried to the house or hauled for occasions of great use as washing or butchering. Only a hand pump was used as the well water was not lifted any appreciable distance. Water supply was described as good and abundant.

Farm nineteen supported one person who was herding cattle and who could not report on the number. The number was large since the farm was described as a ranch and the cattle herd appeared large. There were two wells—one 60 feet and one four feet with the four foot well flowing. The water supply was called good and ample. A windmill was pumping the 60-foot well. Water was carried from the well to the house. No provision was made for winter heating of water for the livestock. No bedrock was reached in the wells.

Farm *X* supported four people and was a truck farm on the bank of the Buffalo River. The farmer used the river and a well for water supply and had no cistern. The well was reported as shallow with the water piped into the house. The river water was piped to the truck patches and was used to irrigate the growing vegetables. The farmer had an icebox which he could readily supply with ice in the hot summer months due to his frequent visits to Moorhead with his fresh vegetables. He had an engine for pumping the water. He had no livestock and bought his dairy products.

Farm twenty was a dairy farm with 63 cows, nine horses, and 26 sheep. They had a well 160 feet deep pumped by a windmill. The water was piped to both house and barn and the cows had individual drinking cups with constant water supply. A cooling tank was used for refrigeration being kept cool by the well water. The water level in the well was at the surface but the well did not actually flow. The well did not reach bedrock.

Farm twenty-one supported three

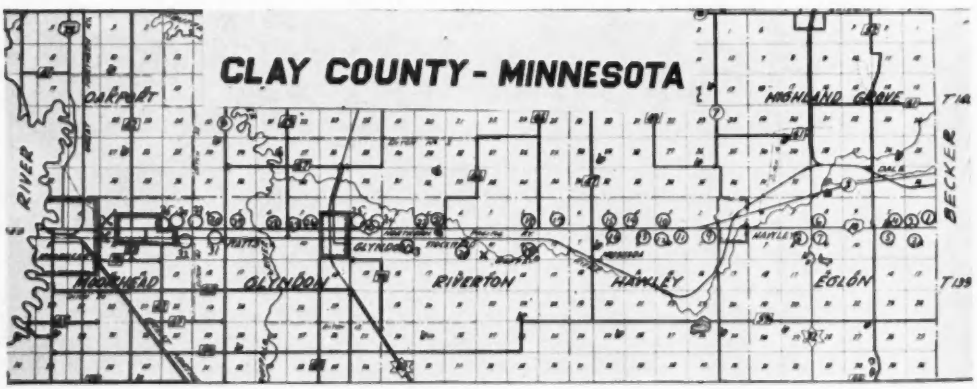


FIGURE 25.—Map of farm locations visited in Clay County in a traverse across the Red River Valley investigating farm water supply and use.

FIGURE 26.—Map of farm locations visited in Cass County in a traverse across the Red River Valley investigating farm water supply and use.

people, 20 cattle, and five horses. The water came from a well 130 feet deep and from the Buffalo River. The well water supply was called ample and of fair quality. The lift of water was small and handled by a hand pump. There was a pump in the barn for winter supply with a barn tank. An outside tank was used in summer with the river supplementary.

Farm twenty-two supported three people and three cows. The water supply came from both well and cistern with the water piped to both house and barn. The water was called abundant and good. The water supply in the barn froze at times in the winter. The well was 100 feet deep with no bedrock reached. The well did not flow but a hand pump was all that was needed for the small lift of water since the water rose high in the well.

Farm twenty-four supported two people, four cattle, one horse, one sheep and one hog. The water supply came from a 115-foot deep well which flowed at first. The water level was still about at the surface. An engine was used to pump, and the water was piped to the house. The supply was ample and good. No bedrock was reported.

Farm twenty-five was small and two people were present at the time of the survey. Two wells were reported with no data given. A cistern was in the house. Little farming appeared to be done with no livestock reported.

A stop was made at the Teacherage in Glyndon. The Teacherage and school was supplied with a pressure system. During the approximate half hour visit about 15 pails of water were carried from the Teacherage by villagers. The water was drawn into the pails from a tap on the side of the house and from the sink of the Teacherage.

Farm twenty-six supported seven people, 25 cattle, and eight horses. The water supply came from two wells and a slough. The water was carried to the house. The well depth was not given. An outside water tank supplied the livestock. A water cooler was used for refrigeration.

Farm twenty-seven supported seven people, 25 cattle, and four horses. One well and a cistern supplied the water. The well was 152 feet deep and was pumped by an engine. Water was carried to the house. The well was described as pumping dry on hot midsummer days. The barn was supplied with drinking cups for the cattle. The cups were kept full of water by a pressure system. The farmer stated that his cattle did better on less feed with the cup water supply, and particularly emphasized the convenience of the cups in time and effort. No bedrock was reached.

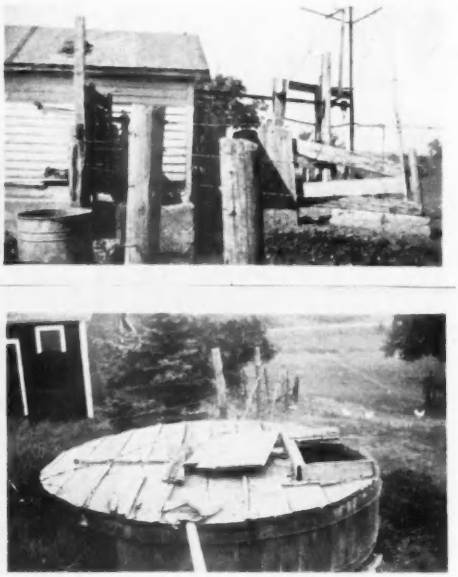


FIGURE 27.—The pump and pasture tank for farm one.

No one was at home on farm twenty-eight.

Farm twenty-nine supported eight people, 75 cattle, and ten horses. Water was supplied by well and cistern. The well was 84 feet deep and pumped by engine. The water was piped to both the house and the barn. The livestock used an outside tank in summer and a barn tank in winter. The farmer hoped to irrigate his crops by pumping water from the Buffalo River although, he expressed an alternative by drilling a well on the higher land away from the river and irrigating by gravity the crops growing on the riverward slope. He also stated that the wells formerly flowed in this vicinity but ceased to flow after the Northern Pacific Railroad drilled in their well for water supply and began pumping at the rate of 50,000 gallons per month.

Farm thirty supported four people, 12 cattle, six horses, and 60 hogs. Water supply was from a 180 foot well pumped by a windmill. The water was piped to the house and barn, with drinking cups in the barn for the cows. The water supply was called abundant and of good quality. An outside tank was used for the livestock in summer.

Farm thirty-one supported 11 people, 75 cattle, two horses, 30 sheep, and 100 hogs. Two wells at 85 and 150 feet supplied the water—being pumped by a windmill and an electric motor. The water supply was stated as ample and good. Water was piped to both house and barn. Since the farm was not a dairy farm the barn supply of water was not in constant use. The farmer had plans to establish well water irrigation.

Farm thirty-two, no report. No one was at home.

Farm thirty-three reported 75 cattle. Water supply came from a 200 foot well pumped by an engine with the water piped to both the house and the barn. The livestock was watered from an outside tank in summer and barn tank and cups in winter.

Farm thirty-four, no report. No one was at home.

Farm thirty-five supported five people, 60 cattle, four horses, and 20 hogs. The water was supplied from a well of possibly 87 feet in depth pumped by a windmill. The water was carried to the house and the livestock had an outside tank in summer and a barn tank in winter. The water was called good and of abundant supply.

Farm *X* south of the highway adjacent to Moorhead was a dairy farm of 60 cows. The water was supplied by 156 foot well pumped by both windmill and engine. Water was piped to both the house and the barn with a barn tank for livestock. The water level has been gradually lowering in the well. Twelve years ago it was 18 feet from the surface while now it is five feet

from the bottom having lowered 133 feet in that time.

Farm *X* north of the highway adjacent to Moorhead supported two people, 11 cattle, four horses, and 12 hogs. The water was supplied by a well and supplemented by hauling from Moorhead city supply when the well pumped dry. A windmill lifted the water. The well depth was not known.

Farm thirty-six was in Cass County, North Dakota, the first farm visited west of the Red River. This farm was near Fargo and supported 12 people, four cattle, and four horses. Their water supply came from a surface well 16 feet deep which held up fairly well, and a cistern. They had a deep 160 foot well but it had failed. Water was hauled from Fargo to supplement their supply. The livestock were supplied with water in the barn by using barrels. No provision was made for water conveniences of any kind. The 160 foot well did not reach bedrock.

Farm thirty-seven supported 15 people, 25 cattle, 400 to 500 sheep, and 30 to 40 hogs. The only water supply was a well, 115 feet deep. The water was described as abundant and very good. Water was piped in the house and the livestock drank from an outside tank which was kept open in winter by a tank heater. Power for lifting the water was supplied by an electric engine. They did not irrigate crops but watered the lawn from the well.

Visit thirty-eight was the WDAY radio station which supplied their entire plant and landscaped grounds from a well. No other information was available.

Visit thirty-nine was to a residence with a 133 foot well which was stated to have enough water to supply fifty homes. The water was called soft and very good tasting. It was being pumped by an electric motor and all-day pumping did not reduce its level. It is probable that a line of suburban homes will be later connected with this supply.

Visit forty was a filling station and a group of five suburban homes connected to one 104 foot well. This well was pumped by an electric engine and supplied these homes with every need even to irrigating their lawns and gardens and also supplied the filling station. The water was described as soft, good tasting, and the well as not lowering in level even with all day pumpage.

Farm forty-one supported eight people, 150 cattle, and 10 horses. The water supply came from a well 200 feet deep and a *BARN CISTERN*. This was one of two barn cisterns encountered by the writer in this rural water supply survey. The absence of barn cisterns was unusual to the writer since barn cisterns prevailed as livestock water supply in Southeastern Ohio, his boyhood home. It is realized that the rainless winter and droughts in summer would make a barn cistern undependable, nevertheless, a very large supplementary supply could be obtained from the roofs of the huge barns of the Red River Basin. This angle of water supply in the basin deserves some attention. The well provided plenty of good water and was piped to both house and barn. The freezing problem was cared for by pumping the water only when the livestock were allowed freedom to drink.

Farm forty-two supported two families of 13 people, nine cattle, three sheep, and 34 hogs. A well 100 feet deep and a cistern supplied the water. The well water was carried to the house but the cistern was pumped by a house pump. Livestock was watered by an outside tank equipped with a heater in winter. The supply of water was abundant and

FIGURE 28.—Plate A above shows windmill pump, cold water refrigeration tank and watering tank on farm 8 in eastern Clay County. Plate B shows pasture windmill pump, watering tank, and cattle herd on farm 18.

good. No bedrock was reported. A gas engine supplied the power.

Farm forty-three supported five people, 35 cattle, and two horses. The water came from a well 147 feet deep and a cistern. The cistern was connected to a house pump. The livestock drank from an outside tank with a coal heater for winter. A water cooler was used for milk. The water was abundant and good but the water level was said to be falling in the well. A gas engine was used for pumping power. No bedrock was reported.

Farm forty-four provided no other information than a 60 foot well with adequate water.

Farm 45 supported two people, 25 cattle, four horses, 25 sheep, and 18 hogs. The water was supplied by two wells and a cistern. One well was given as 95 feet deep while the other was not reported. Water from both well and cistern was piped to the house. The livestock drank from an outside tank kept free in winter by a heater. The water supply was described as adequate and ample. A water cooler supplied refrigeration. A windmill pump and two gas engines were used for power. No bedrock was reported.

Farm forty-six provided no information.

The village of Mapleton was visited and the school water supply investigated through the courtesy of Mr. Walter Fogle, school Superintendent. The school is equipped with its own pressure system. The water for this system is supplied from a 280 foot well which reached a bedrock aquifier probably the Dakota Sandstone. This well was supplemented by a huge cistern. This cistern water was mixed with the well water (half and half) for use in the school boiler. The cistern held an all-winter supply and is very suggestive of the value of cisterns as a supplemental water supply.

Farm forty-seven supported six people, 60 cattle, 10 horses, and 50 hogs. The water supply came from two 70 foot wells and an outside cistern. Water was carried to the house and the livestock drank outside with the tank being banked in winter for freezing protection. Fear was expressed that the water supply would fail although for the present it was adequate. The quality of the water was given as inferior due to minerals, particularly iron (possibly due to old pipes). No bedrock was reported.

Farm forty-eight supplied no statistics as no one appeared to be at home. There was a well in the yard with a well house and pump, and an open tank for livestock.

Farm forty-nine supported nine people, 25 cattle, eight horses, and 30 hogs. Water came from a 500 foot deep artesian well and a cistern. The water from this flowing well was piped to all

places needed including the pasture tank. The pressure was adequate to keep the water flowing at all times and no provision was necessary against winter freezing excepting a tank heater where the water was accumulated outside in the tank. The well was stated to be fifty years old. The water was described as good and abundant. The well was drilled into a bedrock aquifier and while not stated, was likely the Dakota Sandstone.

Farm fifty supported 40 cattle, 27 horses, 400 sheep, and 50 hogs. Water came from two 400 foot flowing wells. The water was piped everywhere desired. The flow of these wells was stated to be growing weak. Livestock drank from an outside tank in summer and a barn tank in winter. The only statement about the water supplying formation was that it was sand (very likely the Dakota Sandstone).

Farm fifty-one was visited but no one appeared to be at home. Water was flowing from a ground pipe and a flowing well was likely the supply. The water was piped to an open tank for livestock. (Figure 29, plate A.) The herd of cattle appeared quite large.

Farm fifty-two supported three people, eight cattle, five horses and 18 hogs. Water was supplied by a 371 foot flowing well. The age of this well was given as 20 years. When the well was first drilled, the pressure "Shot the water as high as the barn." This pressure weakened and the water was brought under control. The supply appears more than adequate for all farm uses and an over-flow pipe is provided. (Figure 29, plate B.) The quality of the water was called good with some mineral and at times roilly. The water was piped to the house and to an outside tank for livestock. The water supply formation was given as bedrock but no

FIGURE 29.—Plate A above shows an artesian well head and watering tank in the near-by pasture. Plate B below shows an overflow pipe from an artesian well. Farms 51 and 52.

statement other than that could be given.

Farm fifty-three supported four people, 12 cattle, eight horses, and 73 hogs. Water supply came from a deep flowing well. The depth was not given but the water was stated to be abundant and of good quality. Bedrock was reported as the aquifier. Livestock drank from an outside tank. Two cisterns supplemented the water supply.

Farm fifty-four supported two people, 14 cattle, two horses, and 18 hogs. Water was supplied from a flowing well with no information as to depth available although no bedrock was reported. The water was piped where needed in the house and to an outside tank. The tank was banked in winter for freezing protection. The water supply was ample and of good quality.

Farm fifty-five got its supply from two shallow wells 30 and 32 feet deep, one of which had become exhausted. The supply from these wells was inadequate and had to be supplemented

by hauling both winter and summer. A tub caught rain water at the house eaves spout and ice and snow were melted in winter.

Farm fifty-six supported 12 cattle, six horses, 600 sheep, and 60 hogs. Water supply came from a "very deep" well and a cistern. The well was pumped by an electric motor. The house was supplied with an indoor cistern pump and several outside tanks were available for the livestock—being kept open by a heater in winter. The well water was described as alkaline and hard and the family drinking water had to be hauled. No statement was made as to the water bearing formation of the well.

Farm fifty-seven supplied four people, 12 cattle, five horses, 60 sheep, and 10 hogs. A shallow well 20 to 40 feet deep and a cistern supplied the water. The water sufficed but more could have been used. No bedrock was reported. Water was carried to the house and the stock drank from an outside tank kept from freezing in winter by a tank heater.

Farm fifty-eight supported four people, five horses and 46 hogs. Water came from two shallow wells and one cistern. The wells were 18 feet deep. One well was dry but the other was providing enough water for the present consumption. Water was carried to the house and provided to livestock by an outside tank kept open by a tank heater in winter.

Farm fifty-nine supported the family and several neighbors with household water supply. The number of people included was not stated. In addition the farm kept 24 cattle, one horse, 200 sheep, and 10 hogs. Water was supplied by a 22 foot well stated to be 40 years old. The water supply from this well was stated to be ample and of good quality. Water was piped to the house but was available for livestock in an outside tank kept open in winter by a tank heater. An engine pumped the water.

Farm sixty supported seven people, 20 cattle, 10 horses, 40 sheep, and 20 hogs. Water was supplied by a shallow well and a cistern. Water supply was given as ample and good. An indoors cistern pump supplied the house—drinking water was carried. An outside tank supplied the livestock together with a tank heater for winter.

Farm sixty-one supported five people, six cattle, six horses, and 40 hogs. Water supply was ample and good from one well. No statement was made as to depth of well and bedrock. A cistern pump supplied the house and drinking water was carried. Livestock drank from an outside tank equipped with heater for winter. An electric motor pumped the water.

Farm sixty-two supported 10 people, 79 cattle, 30 horses, and 100 hogs. Water supply came from a 505 foot flowing well and a cistern. Water was piped all places where needed and was available at all times as it "never freezes." Tanks were available both in and outside the barn. The well water was described as coming from bedrock with no information as to its name. As with other artesian wells no power was needed for water lift as the pressure carried the water everywhere desired. The supply was called abundant and satisfactory.

Farm sixty-three was supplied by a 500 foot flowing well. The well was given as 28 years old and the water still abundant and of good quality. The water was piped where needed but does freeze occasionally.

Farm sixty-four supplied seven people, 30 cattle, 15 horses, and eight hogs. Water supply came from two wells one of which was 718 feet deep and was just drilled in. This deep well was a flowing well and was being piped to both house

and barn. The first well was 60 feet deep and had kept the farm supplied with water until recently. One cistern was arranged so as to provide water under pressure. The deep well drew its water from bedrock with no knowledge available as to its designation.

Farm sixty-five supported seven people, 70 cattle, 20 horses, 10 sheep, and 50 hogs. Water came from a 700 foot flowing well which water was described as abundant and good. The water was piped where needed but a cistern supplied soft water by a house pump. The well was stated to be 35 years old and had not diminished in its flow.

Farm sixty-six supported seven people, 80 cattle, 15 horses, and 50 hogs. A 600 foot artesian well supplemented by two cisterns supplied the water. The artesian well formerly flowed through pipes "All over the farm" but has weakened and now has to be pumped by an electric motor. The house had a cistern pump indoors and the barn had a cistern supply. An outside tank was available for livestock in summer. Drinking water was hauled from the town of Buffalo. The well drew water from bedrock.

It is evident that while this detailed field work as a whole supports general summarizations and generalizations in water supply and use on the farms yet in its distribution from farm to farm there are innumerable variations. Even adjacent farms may not have the same equipment or the same water supply arrangements. One will use a windmill pump, the other a gas engine, one will have a house cistern pump, the other carry the water, one will have a barn tank, the other an outside tank and heater, one will have 100 sheep and no hogs, the other 50 hogs and no sheep. However, the dependence on well water is common to all. The two supplementary barn cisterns may suggest a possible future alternative.

FIGURE 30.—A windmill by the house or barn of the Red River Basin farmstead is part of the rural cultural landscape.

Mr. William Peterson, Instructor at the Sharon, North Dakota high school made a study of the farms about Sharon in Steele County for the writer. Thirty-five farms were covered and the same questionnaire form was used as was used by the writer in his field work. The information obtained was quite similar to that obtained by the writer in his Cass County survey and since space is limited in the present survey the detailed results and summary are not included here.

A farm water supply study was made in 1936 by W. W. Felson, Auditor of Pembina County. Two thousand post card questionnaires were sent out to the Pembina County farmers. This survey revealed a drop of six feet in water table in Pembina County at that time. Wells were the primary source of supply, with dugouts, cisterns, springs, creeks, and lakes as supplementary sources. The survey showed at the time that water shortage had reached serious proportions in Pembina County. 384 farmers reported a water supply shortage with an average duration of 4.81 years. In providing water for livestock under such conditions 249 farmers reported the average distance from their farm to a source of water supply to be 2.82 miles. Needless to say that such a

water supply handicap will eventually cause abandonment of the farms or a marked curtailment of their livestock enterprises.

An interesting phase of the Pembina survey was the alternative water supply suggestions made by farmers with 365 offering remedies. The first remedy was the construction of dams in streams and coulees. The second remedy was an extension of well drilling to more numerous wells and at a greater depth with better construction. The third remedy was for more, larger, and deeper dugouts. The fourth suggestion was simply more rainfall. Among the variety of other remedies 2.8 per cent suggested larger cisterns and 0.6 per cent suggested pipelines from such water supplies as rivers.

BRITISH RAILWAYS AND MOTOR ROADS IN THE MIDDLE EAST, 1930-1940

Morton B. Stratton

THE decade of the 1920's had witnessed the rise and fall of interest in a Haifa-Baghdad railway and the imminent inauguration of a rail-bus service from Europe to Iraq along the path of the former Baghdad railway. The decade of the 1930's saw a second wave of interest in a Haifa-Baghdad railway, and the virtual completion of the Baghdad railway. It is interesting to observe how the original German conception persisted in the face of British opposition and eventually won out over the pet project of British statesmen in an area they controlled—a mechanized version of the fabled race between the tortoise and the hare. There was one important difference between the Haifa railway of the 20's and that of the 30's: the original project had been supported only by the British government, whereas the revised version was also keenly desired by the semi-independent Government of Iraq.

The considerations which made a railway from a British port on the Mediterranean to Iraq desirable immediately after the World War were still operative in 1930 when the plan achieved renewed prominence. The economic revival of Iraq and Persia had materialized to a certain extent and the desirability of direct access to their raw materials, food-stuffs, and markets had correspondingly increased. The chances of extending a railway to Iraq on through Persia to India were now nil, but the popularity of the desert bus route for passengers travelling to Iraq, Persia, and India proved the utility of a short route to Iraq for the world's passenger traffic. With reference to these two factors, trade and passenger traffic, the *Railway Gazette* observed in 1930: "This new route will, it is anticipated, open up an alternative route from Europe not only to Iraq but to the Far East. . . . The new line will divert a considerable volume of Middle Eastern trade from the Suez Canal and will probably attract many passengers from India who would appreciate a change from the usual sea route." As regards the all-important strategic advantages of an alternative to the Suez Canal, they had been considerably increased as the development of the airplane for military purposes made the Canal more liable to destruction in time of war. The two chief obstacles to the realization of the Haifa-Baghdad railway in 1922 had by 1930 been largely removed. The return of a measure of prosperity to Great Britain put her in a position to consider more elaborate plans of imperial development; the conclusion of treaties with Ibn Saud of Nejd had defined the limits of the Iraq-Trans-Jordan corridor and had brought a considerable measure of peace and stability within its borders.

The Haifa-Baghdad railway by 1930 promised very real advantages to the Arab Government in Iraq. The decision of the nationalist government in Persia to divert her trade with Europe from Iraq routes to a Persian port on the Gulf was resulting in a severe curtailment of Iraq's transit trade. Many Baghdad merchants engaged in the entrepot trade with Persia were eventually forced out of business. The decline in Iraq's transit business threat-

ened to become worse when Reza Shah Pahlavi decided in 1927 to construct a railway from the Caspian to the Persian Gulf. The best remedy for Iraq's dilemma seemed to be the Haifa-Baghdad railway. If it could be built before the Persian railway was completed, it might succeed in attracting the Persian trade to itself. Iraq statesmen had sensed the situation almost immediately. The Iraq representative to London was reported to have told an interviewer in the spring of 1927: "Ora che la Persia intende collegare il Caspio al Golfo Persico mediante ferrovie, è necessario che l'Irāq, per impedire che tale linea danneggi il suo commercio, abbia al piu presto una ferrovia transdesertica che, passando per la Siria, metta capo al Mediterranco." This solution was pressed on them in 1930 in Sir Edward Hilton Young's report on Iraq's financial and economic position. He strongly urged the necessity of Iraq developing more direct contact with world markets than by the Gulf. "The best way to remedy 'Iraq's geographical isolation," he recommended, "is the construction of the Haifa railway, and it is this that should be the end of Government policy in the matter. This is one of the brightest hopes for the future. The Haifa railway will set the tides of modern life running straight through 'Iraq." Young advised Iraq to finance the railway by borrowing foreign capital, but if this were impossible "an undertaking to construct the Haifa railway might be obtained as a term of an oil concession."

Iraq was already well aware of this latter possibility. Unquestionably the primary reason for the emergence of the Haifa-Baghdad railway was its close

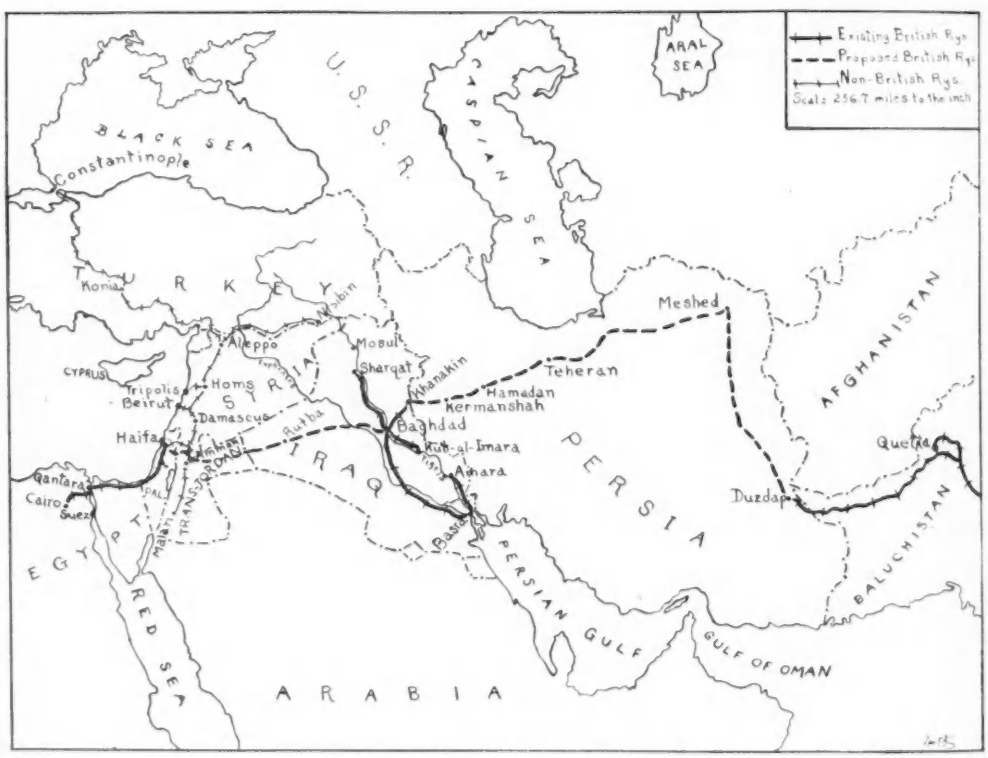


FIGURE 1.—Railways in the Middle East.

relationship with the proposed Iraq-Mediterranean pipe-line which by 1930 was being strongly pushed by Great Britain and Iraq alike. But both the pipe-line and railway were dependent on the existence of an adequate terminal port on the Palestine coast. This latter had been in process of creation virtually since the war and it will be best to consider its history first before turning to the development of the former.

The spot chosen as the future terminus for the railway and pipe-line was the port of Haifa. Trial borings and a preliminary survey of the harbor had been begun in 1920, the year the British civil era set in, showing in the words of *The Near East and India* "that British administrators realized early in the history of the post-war government of this country [Palestine] the potentialities of the town." In developing the port they had in mind its importance as a gate to the vast hinterland of the Middle East. Contractors of many nationalities presented schemes, some of them very elaborate, for harbor development. Feeling the need of advice the Palestine Government made arrangements with the Colonial Office which in 1922 engaged the prominent engineer, Mr. Frederick Palmer, of the firm of Rendel, Palmer & Tritton, to visit Palestine, and draw up recommendations. His "Report of the Provision of Harbour Facilities for Palestine, 1923," was presented in July, 1923. He advised the construction of harbors at Jaffa and Haifa, each to cost £1,000,000, and drew up a definite plan for the harbor at Haifa designed to take care of present and future trade.

After consideration by the Governments of Palestine and Great Britain Parliament in 1926 guaranteed a Palestine loan of £4,500,000, £1,000,000 of which was set aside for the Haifa harbor. In the following years Messrs. Rendel, Palmer & Tritton were appointed consulting engineers for the project. Further surveys were carried out, the estimate raised by £250,000 and the final plans prepared. In 1928 a Railway Board and Harbour Board were created to "focus interest and activity so that broad lines of policy should emerge and be more easily determined." It was decided in 1929 to carry the harbor works out by direct administration of the Palestine Government under the supervision of the engineers and a newly organized Haifa Harbour Works Department. Work began in the spring of 1929 and by 1933 the breakwaters were completed. The harbor was opened formally in October of the latter year. A terminal for the proposed Haifa-Baghdad railway was being built on the quays and provision being made for refueling the British navy and merchant marine from the future pipe-line. Inquiries had been made by the Governments of Iraq and Persia for the provision of free zones and other facilities in the Haifa Harbour Area for transit trade between their countries and the Mediterranean. The appearance of engineers at Haifa in connection with the harbor development had led to the circulation of rumors in the Arabic press that the laying out and construction of the railway to Baghdad were imminent but they were quite unfounded.

With work well under way in 1929 on Haifa harbor Great Britain was ready to push forward the construction of the railway and pipe-line. Iraq was equally ready for the railway, for the reasons discussed earlier, and was actively working for the pipe-line as well. For financial reasons both Great Britain and Iraq wished if possible to have the railway built by the principal oil concessionaire of Iraq, the Turkish Petroleum Company, in connection with the construction of the pipe-line which it

was obligated to build under the terms of its contract. When Sir Edward Hilton Young suggested in 1930 to the virtually independent Arab government of Iraq that it secure the railway as the price of an oil concession he was only urging them to adopt a practise which the virtually British government of Iraq had adopted in 1925 when it granted the oil concession to the Turkish Petroleum Company. Under the terms of that concession the company was to select twenty-four plots of eight square miles each within thirty-two months and to start drilling four months later. When it had become "commercially justifiable" it was to begin the construction of a pipe-line to the Mediterranean. The company was also empowered to construct and operate such railways as might be necessary for the purpose of the pipe-line providing plans were submitted to the government of Iraq for approval and provided also that without the permission of the government no such railway be constructed of a gauge exceeding two feet six inches. If a railway wider than this were built the government might purchase it any time. In time of war the government might use any of the company's railways on payment of compensation. The meaning of these concession terms is clear: with Iraq's approval the oil company might build a metre or standard gauge railway from Iraq to the Mediterranean which would take the place of the railway projected by the British government after the war. This concession was an exact fulfillment of article 7 of the Sykes-Picot Agreement of 1916. It is to be noted, however, that construction of the railway by the company was optional, not obligatory.

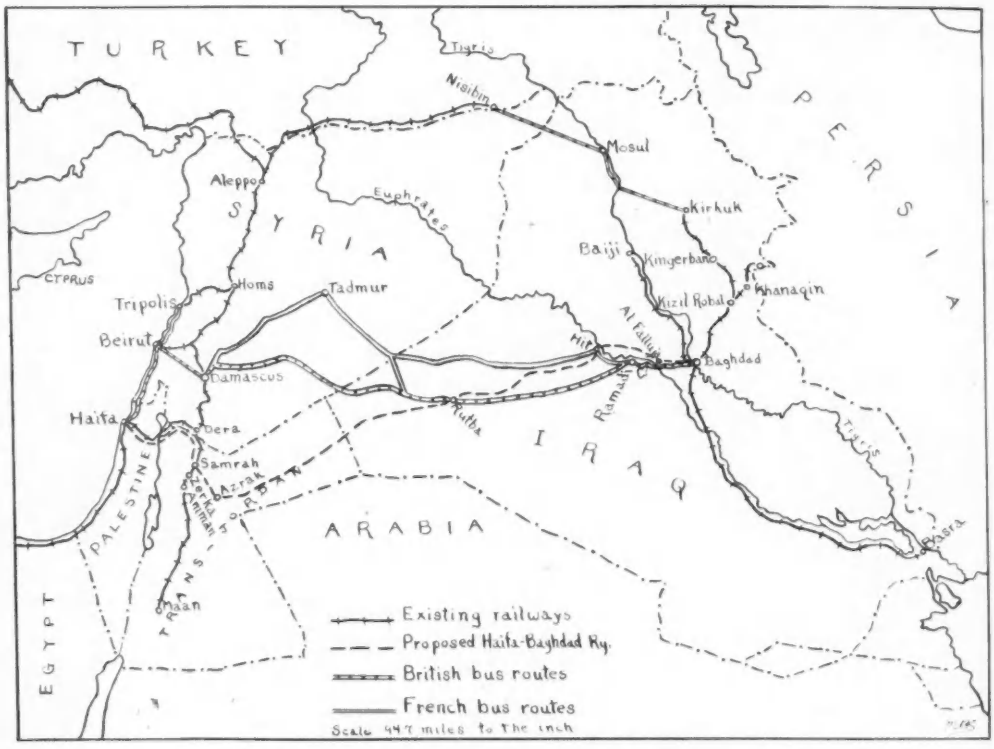


FIGURE 2.—Railways and Bus Routes in the Middle East.

By 1930 the Iraq Petroleum Company had neither chosen its plots nor begun a pipe-line. The government of Iraq, in need of the oil royalties, was anxious for the pipe-line and also keenly interested in the railway which it hoped might revive its own and the Persian transit trade. It was therefore putting pressure on the company to build both immediately as a *quid pro quo* for granting an amendment to the oil concession which the company desired. The latter in its drilling had discovered a tremendous oil field at Baba Gurgur. It feared that the twenty-four plots would not even cover this one area and would allow rivals to tap it as well. It therefore wished the area of its concession increased to include the whole of this field. But it shrank from the expense of building the railway and pipe-line desired by Iraq since it knew the former would not pay for some years to come. This deadlock between company and government was complicated by other factors. France was adamant that the pipe-line go to Tripolis and it was feared that if her wish were not granted she might block the admission of Iraq to the League. Great Britain on the other hand, standing behind the company, was equally insistent that the pipe-line have its egress at the port of Haifa, then being built by Palestine at great expense. Moreover it would have been decidedly inconvenient for the British fleet to be dependent on a Syrian port for oil, quite aside from the disadvantage of having a strategic and commercial railway run through French controlled territory. Finally, a new financial group, the British Petroleum Company was seeking an oil concession from Iraq and was vaguely promising financial aid for a railway in return. No settlement of this complicated tangle had yet been reached in 1930 when the British Government determined to proceed with a careful, detailed survey of the route that the railway might follow.

A grant was made for this purpose from the Colonial Development Fund in August 1930. The survey was performed by the same firm that designed and aided in the construction of Haifa harbor. Engineers were sent out in October and November and began work at once. All told there were 540 engineers and surveyors. They worked under difficult conditions in temperatures varying from 20° F. at 3,000 ft. above sea level to 110° F. in the shade at 830 ft. below sea level. For one hundred and fifty miles their path lay across a country strewn with lava boulders. Transport arrangements were handled by Mr. Nairn. Valuable assistance in the survey was also granted by the R.A.F. and the Royal Engineers. They completed their work in the spring of 1932 at a cost of £100,000.

The route surveyed ran just south of Lake Tiberias, through northern Trans-Jordan, Rutba, Hit, and Baghdad. It was estimated that the railway would take four or five years to build and would cost £7,743,300 for standard gauge, or £7,308,000 for metre gauge, including rolling stock. The average speed of trains would be 33 m.p.h. The problem of gauge was a difficult one to settle. The railways of Palestine, including that from Egypt, were of standard gauge; the railways of Iraq, with the exception of the Baghdad-Baiji line up the Tigris, were of metre gauge; the survey for the Khaniqin-Teheran extension had provided for metre gauge also, but the Persian Government was building the new Caspian-Gulf line in standard; finally the railways of India were of a special broad gauge. The construction of a railway to India in the future in a single uniform gauge would manifestly be very nearly impossible. In so far as this railway to Baghdad was

concerned, if it were built in standard gauge it could carry through cars from Egypt and Europe to Baghdad, but to no other point in Iraq. If it were built in metre gauge it could carry cars from Haifa alone to Baghdad, Basra, Khaniqin, and Kirkuk and would thus serve for the distribution and collection of goods and passengers from a larger area in the Middle East. For the purposes of a strategic line from Haifa to Basra metre gauge would be most satisfactory as it would utilize the existing track and rolling stock between Baghdad and the port on the Shatt-al-Arab.

In addition to the survey Messrs. Rendel, Palmer & Tritton prepared careful estimates of the probable revenues and expenditures of the Haifa-Baghdad railway. They were based on the rather dubious assumptions that 1) Persia would abandon the Trans-Persian railway and join up with the Iraq railways and 2) that the new railway would entirely supersede the desert bus service. The former assumption was particularly open to question as the Persian railway was dictated very largely by political considerations, i.e., by the desire to divert Persian foreign trade from Russian and Iraq routes. Be that as it may, they estimated that the railway would earn four per cent on the capital cost in its eleventh year of operation and that its prospects would hinge chiefly on the development of trade with Iraq and Iran since it would have to depend largely on through bookings, not local traffic, and since Palestine and Trans-Jordan traded mostly with the West. From a purely commercial standpoint the advisability of the Haifa-Baghdad railway was shown clearly to be open to serious question.

By the time the survey had been completed the chances of the railway being built had become remote indeed. The Iraq Petroleum Company had successfully insisted on its inability to build both the pipe-line and the railway. In the settlement of its dispute with the government the two items were definitely separated from one another. The company was granted an enlarged concession area in return for accepting a definite obligation to complete the pipeline by December 31, 1935. A compromise was reached as to its outlet in

FIGURE 3.—Type of country in Northwest Persia where new roads are being built. (British Information Service.)

the provision that it bifurcate west of the Euphrates, one branch debouching at Haifa, the other at another port on the Mediterranean and both to be completed simultaneously. Reluctantly Great Britain and Iraq assumed responsibility for the railway. The Iraq premier announced that his Government intended forwarding a scheme for a railway to the Mediterranean which, it was hoped, would be completed by 1935. To remove any possibiity that the Iraq Petroleum Company might build a railway in connection with the pipe-line that would compete with the Haifa-Baghdad railway the revised concession provided that if it built a railway from its oil fields to the Bay of Acre wider than two feet six inches construction east of the Tigris must not begin before December 31, 1935 and west of the Euphrates before December 31, 1940 unless the Government gave its approval. Should the Government approve it, the Government retained the right to purchase it at any time and to use it in times of national emergency and in war. These provisions were designed to give the British and Iraq Governments ample time to build a Haifa-Baghdad railway under their own auspices if they decided it was feasible.

For financial reasons this was never done; this much is clear, but the details of Anglo-Iraq bickering over their respective shares of the cost are obscure. It must be remembered that in 1931 Great Britain adopted a revised budget and instituted drastic economies in most departments. She was, therefore, once again as in 1921–22 not in a position to afford the luxury of a Haifa-Baghdad railway. Iraq also felt the effects of the world-wide depression although the large increase in oil royalties did make it possible for her to launch a capital works program. The railway was still in its preliminary stages and was not included. Thereafter no agreement was reached with Great Britain on the problem of financing it. In 1934 Iraq was reported to have recently given Great Britain a definite refusal to participate in the railway. Great Britain was planning soon, according to this source, to try and interest the Trans-Jordan legislative council in return for permission to let the Bedouins colonize along the railway. But a year later *The Near East and India* wrote that it was understood the British Government had decided to take no action at the moment to further its construction. In any case it seems to have died a lingering death after 1931 and has not been seriously proposed since, its place having been taken by a Haifa-Baghdad motor road. The emergence of the latter as a possible alternative seems to have dulled the enthusiasm for the much more costly railway project. Foreign comment attributed its death to a number of factors including its uneconomic character, a desire not to offend Arab opinion, and the opposition of the French.

The development of communications in the Middle East since the World War has been characterized by a keen rivalry between the railway and the motor road. Because they are less expensive, roads have in general flourished during periods of economic depression when the cost of railways was prohibitive. During and just after the war elaborate plans for the extension of railways in the Middle East were conceived. The advent of hard times caused these plans to be laid aside. In their place came the establishment of trans-desert motor routes to Baghdad and Teheran. When a measure of prosperity had returned to the countries of the world, railway projects again appeared, particularly the Haifa-Baghdad railway. But a periodic depression once more engulfed the world and the Haifa-Baghdad railway suffered

FIGURE 4.—Pa'yi' Taq Pass in Northern Persia, the rugged country over which the bulk of supplies to Russia are taken. (British Information Service.)

the fate of its predecessors. As a substitute the possibility of a hard-surfaced road over the same course surveyed for the railway was mooted even before the latter had been definitely abandoned. British imperial necessity dictated a short "all-red" route from the Mediterranean to the Persian Gulf.

The desirability of a motor road from a Palestine port to Baghdad through Trans-Jordan had been pointed out very early in the history of trans-desert motor travel. The two chief obstacles standing in its way were the difficulty of clearing a track through the lava country and the relative lack of economic intercourse between Palestine and Iraq. In so far as Iraq traded westward across the desert it was with Syria and particularly with the town of Damascus. The factors working in favor of a Palestine-Iraq road were their common British associations and the strategic desirability of a connecting road in British-controlled territory. During the disturbances in Syria in 1925–26 the Nairn Transport Co. had used the Rutba-Amman-Jerusalem route, but with the advent of more peaceful conditions had reverted to their old track to Damascus. Evidence that the British were nevertheless determined to create a Trans-Jordan route is seen in 1932. In that year an Iraq company organized a motor service between Baghdad and Jaffa via Amman and Jerusalem. Mail contracts were immediately allotted to it by both the Iraq and Palestine governments. As from July 1, 1932, all mails from Europe to Iraq, Persia, and India formerly using the route via Syria were changed over to the new route. It was twenty-four hours faster than the other. Two years later a supplementary mail route between Haifa and Baghdad was organized by a Palestinian company. Significantly enough it used the track later developed as the Haifa-Baghdad road: Haifa, Nazareth, Jisr el-Mujamiyeh, Irbid, Mafrak, Rutba, and Baghdad.

The inauguration of regular mail services to Baghdad by way of Trans-Jordan paved the way for the Haifa-Baghdad road mentally and to a certain extent physically. It was in 1933, the year after the Amman route was opened

and the year after the survey for the railway was completed, that suggestions began to crop up that a road might be substituted for a railway. It was obvious to all observers that negotiations for the latter were becoming snagged on the problem of finance. As time went on the idea of a military highway achieved greater prominence. In 1934 the British government took up with the idea and began work on the section in Trans-Jordan between the Jordan (at Jisr el-Mujamiyeh) and Mafrak. This was done quietly and tentatively, however; the real decision to proceed with the creation of a trunk highway to Baghdad was not taken until three years later. By that time there had ceased to be any possibility of the railway being built.

The Haifa-Baghdad road falls logically into three sections. That portion of it which lies in Palestine had by 1937 already been constructed by the Palestine Public Works Department as part of its program of local road building. Since Iraq had become an independent country the section from the Iraq frontier to Baghdad became the responsibility of the Iraq government. It had already, in 1934–36, asphalted the road from Baghdad to Ramadi—the point of departure on the Euphrates river of all trans-desert routes to the Mediterranean. It was expected that Iraq would finish the remainder of this work to the frontier of Trans-Jordan by the end of 1940. Great Britain undertook to complete the missing link between the Jordan and the frontier of Iraq. The Public Works Department of Trans-Jordan was in 1937 already improving the road from the Jordan to Irbid and it agreed to complete it as a charge to the Colonial Office. It was decided to have the section east of this constructed by the Military Engineers of the War Department as an agency work for the Colonial Office.

It was in June 1937 that Lieutenant-Colonel Briggs was asked by the War Department to prepare an estimate for an all-weather metalled road east of Irbid. His estimates were given final government sanction in October. Work began the next year and was due to be completed in the summer of 1940. The section of the road running through the lava belt utilized in so far as was possible the construction road created by the Iraq Petroleum Co. while laying its pipe-line. This difficult section was done by direct labor under the supervision of Briggs and his successor. The section from the lava belt to the frontier was done under contract by a British firm in Baghdad. In 1939 the road was proceeding on schedule and it was confidently expected it would be finished in 1940 over its entire length. Actually it was not reported completed until 1942.

Meanwhile with the fall of Syria to the British and Free French forces in 1941 Great Britain acquired in the Damascus road another artery uniting her forces in Iraq with those on the Mediterranean littoral. These strategic highways were of the greatest importance. As *Great Britain and the East* wrote in 1939 of the Haifa-Baghdad road: "It is an international benefit, impregnable and everlasting, and another memorial to British enterprise." War gives these routes their present incalculable significance, but it is to be hoped that the return of peace will see their conversion into highways for world trade and commerce, free and open to all nations. Only thus can they achieve their full promise as great trunk highways into the Middle East.

The possibility of a British railway connecting Haifa with the Gulf of Akaba has attracted attention sporadically

throughout the post-war period and deserves brief mention because of its strategic significance. It is difficult to distinguish between fact and rumor, but it is unquestionable that the British gave some attention to this project as an alternative to the Suez Canal. The route had reputedly been first seriously called to the attention of the Government by Lord Kitchener during the war and had played a part in the determination of the British sphere in the Sykes-Picot Agreement. Nothing more is heard of it until 1928. In July, 1925, Great Britain had reaffirmed its authority over Maan and Akaba following the conquest of the Hejaz by Ibn Saud and on August 3 took over the administration of the Hejaz Railway from Amman to Maan. In 1928 questions were asked about a Maan-Akaba railway at a session of the League of Nations Permanent Mandates Commission. Lord Lugard, a British member of the Commission, said it was reported that a proposal had been made to build a railway sixty miles long at a cost of £1,000 per mile. M. Merlin asked for further details as to whether it was really contemplated and if so whether it was necessary. The British representative before the Commission assured it that "no practical proposal had been made to build a railway of this kind" and that Lord Lugard's information was probably taken from the report of some concession hunter. The matter was then dropped and never revived before the Permanent Mandates Commission. But a year later the Cairo paper, *al-Muqattam*, noted a Reuters dispatch stating that a British engineer was reported ordered to study such a railway.

In 1930 the possibility of a Haifa-Akaba railway was definitely recognized in the terms of the Dead Sea minerals concession granted to Palestine Potash, Ltd., a company incorporated in England. It was therein provided that if the Palestine government (which in effect meant Great Britain) constructed a line of railway from the Dead Sea to Beisan (on the Haifa-Damascus railway) or Akaba the rates would be settled by agreement or by a British railway expert. If the government did not construct these railways when the traffic of the company demanded them it would if required by the company grant it the right to build either or both and would grant or expropriate the necessary land. The government would have the final decision as to route and gauge and might purchase either or both if required for public purposes. These last provisions safeguarded the imperial interest at stake in a railway to Akaba. Strangely enough the implications of this concession did not attract the attention of the Arabic press although its terms were published the year it was granted.

In 1934–35 rumors began to circulate that a railway was being seriously considered and even being secretly constructed. From the frequent visits of the British High Commissioners in Egypt and Palestine to Akaba in 1934 the Jaffa paper, *Filastin*, drew the conclusion that England was preparing to establish naval bases at Haifa and Akaba, to join them by rail, and to then abandon Malta and shift the center

FIGURE 5.—Pa'yi' Taq Pass in Northern Persia. (British Information Service.)

Figure 6.—One of the better existing roads in Kurdistan. (British Information Service.)

of her Middle Eastern defenses from Egypt to Palestine and Trans-Jordan. The article went on to say that English merchandise and troops would use the Haifa-Akaba railway to avoid the high Suez Canal tolls or would go by bus to Baghdad. A year later the same paper reported that the shortage of railway cars for hauling citrus fruit was attributed to the military authorities who were using them for the transport of war materials, track, machines, and tools destined for the construction of the Haifa-Akaba railway which was going on under cover of great secrecy since the government did not wish it to be known until it was finished. This story was apparently manufactured out of whole cloth but rumors of the railway appeared elsewhere and aroused great interest "in view of the fact that such a railway would be of tremendous strategic value in case of war, providing a route from the Mediterranean to the Red Sea in the event that war affected the Suez Canal." As a result of a British representative's visit to Ibn Saud in December, 1935, the British were reported to be negotiating with Saudi Arabia for permission to build the railway. This is not as contradictory as it might seem for although the British claimed Maan and Akaba Ibn Saud did likewise and his consent to a railway would be essential if it were to be free from annoying Arab raids.

It is difficult to determine how seriously the British investigated the possibilities of this supplementary (or alternate) route to the Suez Canal. The emergence of Italian power in the Mediterranean threatened the safety of Malta and the preparation of Haifa harbor and the Haifa and Lydda airdromes indicated the increasing dependence of Great Britain on the eastern Mediterranean as a base for her power. A railway from Haifa to Akaba protected by guns along the Mediterranean coast and planes based on Egypt, Palestine and Trans-Jordan would undoubtedly have strengthened her position there and facilitated the defense of the eastern Mediterranean lands if and when communication with the British Isles through the Mediterranean were shut off. In a report on the Palestine Railways in 1936 Sir Felix Pole mentioned this railway as a possibility and the Palestine Royal Commission of 1937 wrote: "The use of that exit [Red Sea] to the East might prove in course of time of great advantage to both Arab and Jewish trade and industry, and we understand that the construction of a railway down the Wadi Araba has been contemplated." It is important to note that this same commission in its scheme for the partition of Palestine suggested that an enclave on the northwest coast of the Gulf of Akaba be put under British mandate (i.e. not in the Arab state) and that there be free transit of goods to the Jewish state (in which Haifa was to be located). A well-informed German authoress wrote in 1936 that a road was being built at top speed from Beersheba to Akaba, presumably as a sort of stop-gap in place of the railway, and that government commissions with large police escorts had examined the Wadi el Araba. But

no railway had yet been constructed by the outbreak of World War II.

With the subsidence of interest in a Haifa-Baghdad railway after 1932 the attention of those interested in the railway development of the Middle East shifted to the problem of completing the last link in the old Baghdad railway system. Of the portion which remained to be built between Tel-Ziouane (on the Turco-Syrian border just east of Nisibin) and Baiji, in Iraq, about one-fifth lay in Syria and the balance in Iraq. The French decision early in 1934 to complete the portion within their mandate revived a question which had lain dormant since the close of the World War. The French had more in mind, however, than merely to push forward the completion of the railway to Baghdad, they looked on their action as the first step in a railway to Persia via Mosul. As the Syrian Minister of Public Works explained in January, 1934, when announcing that the railway would be begun in March: "Questo tratto è il primo de una linea che porrà la Siria in communicazione con la Persia."

This was no new ambition on the part of France. As French High Commissioner in Syria during 1923–24 General Weygand had tried in every way to make the mandate play its important role of the past, that of *Echelles du Levant*, by developing its commercial hinterland. He gave his encouragement to the development of the trans-desert motor route. A Syrian bus company had been but five months behind the Nairn Transport Co. in opening services from Damascus to Baghdad and had created an extension to Teheran in 1924. The idea of prolonging this route to India then developed. In 1924 the French military attaché to Teheran and Kabul explored by auto the route between Kandahar and Meshed. Upon his return he wrote: "Une nouvelle route terrestre des Indes était ouverte aux moyens mécaniques. Nos trois couleurs s'étaient fait connaitre dans des régions où elles étaient ignorées jusqu'alors." The French press was reported to have also greeted a project for a French railway from Damascus to Baghdad as a "new route to the Indies." In 1930 plans for a railway from Homs to Deir-ez-Zor on the Euphrates were said to be fully ready.

It was apparently not until after 1930 that the French turned their attention seriously to the more northerly but shorter route to Mosul that would be created by an extension of the railway east of Tel-Ziouane. A joint Franco-Turkish declaration of October 27, 1932, relative to an accord on the future control of the Baghdad railway, included among the objects to be attained the prolongation of that railway toward the east. In 1934 Turkey and France were reported discussing a railway through Turkey to Persia in view of alleged English opposition to a railway concurrent to the Haifa-Baghdad project; and Turkey was reported planning to join her railways with Iraq by a line from Sivas. Whatever the truth in these rumors the upshot of French interest in a railway to the East was the decision in 1934 to extend the Turkish railway at Tel-Ziouane on to the Iraq frontier. Construction began in March, 1934, and the new line was opened formally in May of the following year. With the appearance of the railway to Europe at Iraq's very border and only 11 km. from Mosul the temptation to complete the line to Baghdad and open a direct outlet for her goods to the Mediterranean and the continent became irresistible.

Had it come five or even two or three years earlier there is a strong probability that pressure from Great Britain would

have prevented the realization of this project. But by 1935 the situation had altered to its advantage. On the political side it is to be noted that Iraq in 1932 became in theory a completely sovereign and independent state. Great Britain was no longer in a position to directly control her actions as she had theretofore. It is possible that Iraq might have carried through the completion of the Baghdad railway even in the face of British opposition. But Great Britain was no longer as strongly opposed as she had been. The old wounds which aggravated Anglo-French and Anglo-Turkish relations had to a considerable extent been healed. The rise of a fascist bloc in Europe served to cement the nascent Anglo-Turkish friendship and the partnership with France after 1935. It no longer seemed so dangerous to permit the union of Iraq, in which the British Empire had such vital stakes, with Syria and Turkey.

From a strictly economic point of view, moreover, this proposed railway connection had become desirable. The gradual abandonment of the Haifa-Baghdad railway project removed the British fear of two concurrent lines to the Mediterranean. But it also left without solution Iraq's pressing need for a shorter railway outlet to Europe for the Persian transit trade and her own exports. Having failed to realize her own plan for a railway to the Mediterranean Great Britain could hardly refuse, even were she able, to grant Iraq's request for a railway through Syria. Quite aside from this was the necessity of linking Mosul with Baghdad and Basra. As the British administration itself pointed out in 1932 the extension of the Iraq Railways to Mosul was absolutely essential after the hauling of pipeline supplies was over if they were to continue to function as a separate economic unit, for they paid no interest on capital.

FIGURE 7.—A convoy of vehicles on their eight day journey northward to Russia after leaving Andimishk where all motor parts brought from the coast by rail are assembled by Persian workmen. (British Information Service.)

The desirability of the proposed extension was further increased when the British Oil Development Company struck oil south of Mosul which was too heavy to pump through a pipe-line to the Mediterranean. At the same time the company's need offered to Iraq an opportunity to have the railway built without cost to itself. It was this situation more than anything else which led to the completion of the Baghdad railway after 1935. By the terms of its concession of 1932 the company was granted the right to build railways necessary for connecting its oil structures west of the Tigris and north of the 33rd parallel with the railway system of Iraq or the sources of supply of materials, provided it get the consent of the government and provided also that the government should have the right to purchase any railway over two feet six inches wide and to use any of the company's railways in national emergencies or in time of war.

The Syrian extension had been inaugurated in May 1935. Within a month rumors were current in Baghdad that B.O.D. proposed building a railway

direct from their fields at Qaiyara, south of Mosul, to the French railhead at Tell Kotchek. The Iraq government was said to be stipulating that the railway must start further south at Baiji and that there must be a branch line to Mosul. Although the Secretary of the company in London declared this information "premature and inaccurate" it seems to have been substantially correct. In July an agreement was signed between the British Oil Development Company and the Iraq government providing for the construction of a railway from Baiji to Tell Kotchek via Mosul. Although its main purpose from the company's point of view was to convey oil to the port of Alexandretta it was at the same time of great potential significance for the development of British communications in the Middle East and for the economic prosperity of Iraq. The last possible obstacle to its construction was removed in March 1936 by the signing of an agreement transferring the legal ownership of the Iraq Railways to the Government of Iraq in return for a payment of £400,000 to Great Britain and the constitution of a Board of Management two of whose five members should be British subjects during the next twenty years. Iraq was at last assured of the ownership of her railway system and could proceed uninhibited with its development and extension.

Work on the last gap in the Baghdad railway was inaugurated by the Prime Minister of Iraq on November 20, 1936. It was completed in July 1940 after the outbreak of war in Europe. The northern section between Tell Kotchek and Mosul was finished first, the Taurus express steaming into Mosul on March 31, 1939. The stretch of one hundred and twenty miles between Mosul and Baiji progressed more slowly due to a tunnel 1,039 yds. long and to broken country involving deep rock cutting. But on July 17, 1940 the first train left Baghdad for Haidar Pasha. The new line had taken four years to build and had cost £3,250,000. With its inauguration railway communication between the Bosporus and the Gulf was at long last a reality after fifty years of diplomatic bickering. But its full promise has not yet been realized for on May 27, 1940, two months before its inception and the day after the capture of Boulogne by the Germans, the Paris-Milan section of the Simplon-Orient Express was suspended. Furthermore with the then imminent possibility of a German advance through Turkey it became a two-edged sword. At the time of writing it is an invaluable aid in the Allied defense of the Middle East and may well prove of vital importance in the final advance on Hitler's "Fortress Europe."

Not content with merely linking up their system with that of Europe the Iraq Railways in 1938 announced a £17,500,000 development designed to provide a seven-day service between London and Karachi. Since silt made the Shatt-al-Arab difficult to navigate Sir John Ward, Director General of the Iraq Railways and port director of Basra, proposed extending the railway from Baghdad to Basra on to Fao on the Persian Gulf and the building of a new port there. A fleet of three fast steamers would be built especially for the service between Fao and Karachi. When this was done and the Baiji-Tell Kotchek line was completed it would be possible to save a fortnight on the journey to India. Iraq would become the land junction as well as the air junction for travel to India. No progress has as yet been made on this scheme. It was, however, reported in the *New York Times* in March 1940 that the next step in the strategic link of Middle Eastern

communications would be the conversion of the Baghdad-Basra railway from metre gauge to standard gauge so that goods could pass from Haidar Pasha to the Gulf and vice versa without transhipment. It should also be noted that in 1939 the Turkish Assembly voted £700,000 for a train ferry service across the Bosporus. Future developments and the use to which they will be put depend entirely of course upon the outcome of the present world conflict.

HIGH-COUNTRY "RUN"

THE GEOGRAPHY OF EXTENSIVE PASTORALISM IN NEW ZEALAND

K. B. Cumberland

NEW ZEALAND has a wide reputation for the quality and quantity of its dairy products, but the Dominion is not by any means a land only of intensive dairy farms. Dairy farming is areally restricted. It is located only in a few regions small in size, low in elevation. Here exotic pasture grasses and clovers have been made to support an intensive economy on holdings of 25 to 200 acres. Dairying is a most specialized practice and butterfat almost a monocultural product.

It is other kinds of agricultural occupance that occupy large areas in New Zealand. In practically all these sheep—not cattle—play the most important part. Such is the case in the deeply dissected, Tertiary "hill country" areas of the North Island. There Romneys are reared on hand-sown pastures where forest stood indigenously under conditions of heavy rainfall. Such is also the case on the arable plains of the South Island, where—in rain-shadow areas of periodically deficient precipitation—the farm economy is essentially mixed, and cross-bred sheep and lambs are fattened on rotational pasture grasses, cruciferous crops, and other cultivated fodder.

The extensive pastoralism of the South Island tussock high country occupies the greatest area. Its economy and practices extend further back into the history of European occupance than those of any other type of agriculture in New Zealand; and they do so with least change and modification. The runholders were operating over the greater part of the mountain grasslands of the South Island eighty years ago. The dairying areas of the North Island persisted as swamps and forested Maori strongholds for another thirty or forty years.

This extensive grazing economy is based almost exclusively on sheep, predominantly of merino blood. The scene of it is the leeward flank of the Southern Alps extending in a relatively narrow belt from Marlborough to Southland (Figure 1). It is a country of steep, broken slopes, sparsely covered with a carpet of yellow-brown steppe grasses and topped by massive, grey slides of talus and frost-bitten rocky pinnacles. Its relief is intense. Flat-floored, shingle strewn valleys penetrate deeply between mountain masses eight, nine, and ten thousand feet high. At such elevations glaciation is still active. Here and there wide, gravel-floored basins occur. Their smooth and shallow terraces of glacial and fluviatile debris contrast sharply with the deep and angular dissection of the rocky mountain walls which abruptly enclose them.

This expansive area of mountain range is held mainly by the Crown and in part by educational institutions. It is a huge national asset which, despite very considerable deterioration, still carries almost 2,000,000 sheep on its 7,700,000 acres. It is leased to graziers

FIGURE 1.—New Zealand Tussock Grasslands. The Grasmere-Cora Lynn area depicted on Figures 2, 3, 4, and 5 is here picked out in black.

in large blocks ("pastoral runs") on relatively short term. In Marlborough, Canterbury, Otago, and Southland, the Crown leases 545 such runs, with an average extent each of over 14,000 acres. Individual holdings sometimes total more than 100,000 acres and the South Island high country accommodates at least nine flocks each of over 20,000 sheep. The runs are utilized for extensive pastoral purposes without exception. They produce little other than fine wool and store sheep. (Most prominent of the subsidiary items derived from such country are deer and rabbit skins).

The earliest immigrant sheepmen were quick to realize the grazing potential of these tussock grasslands. By employing English matches, Australian merino ewes, Scottish shepherds and sheepdogs, and a wealth of courage and confidence, the "squatters" quickly evolved methods of utilizing the high country and soon became a prosperous, influential and aristocratic community. Their methods remain. Experience has shown that they were not necessarily the best and they have meanwhile been employed with less skill than formerly. In 1920 a Government Commission appointed to investigate the deterioration and declining carrying capacity of the pastoral lands of the South Island reported that, while "lowland farming in New Zealand has made tremendous strides forward, that of the mountain sheep stations has not merely shown no advance, but has gone backward . . . a state of affairs not at all creditable to the Dominion." It has been repeatedly demonstrated ever since 1869 that the high country methods and practices in question are basically responsible for the runholder's many current problems and the doubtful future of extensive pastoralism in much of the steppe back country.

In view of the seriousness and extent of their contemporary problems and with the possibility, if not the probability, of imminent and extensive change in their use and occupance, it is appropriate to examine in detail the farm economy and grazing practice of one of the high country pastoral runs with the object of understanding and assessing the possible future of the tussock grasslands as a whole. The following outline study is based both on field investigation and an examination of the scanty historical material available.

THE GRASMERE-CORA LYNN RUN

Grasmere and Cora-Lynn, though separate leases, are operated as a unit. They are contiguous, and together form part of the Waimakariri basin. They both lie astride the only transalpine railroad—that linking Canterbury and Westland. The railroad settlement of Cass, with its half dozen cottages, is

located in the heart of the Grasmere holding. The railroad and main trans-island highway make for far greater accessibility than is typical of the rest of the pastoral back country of New Zealand. The runs are located on the inner margin of pastoral settlement and both abut onto the unoccupied Arthur's Pass National Park and the main alpine divide.

Grasmere is an educational endowment under the control of the Canterbury University College Council. It comprises approximately 13,620 acres of leasehold and over 980 acres of freehold. Cora Lynn is a Crown Lease of 19,700 acres (plus 3,154 acres of Occupational License) under the administration of the Department of Lands. In addition, some 9,720 acres of effective grazing located on river flats and alluvial fans are leased from the National Park trustees and 6,000 acres of former bush country from the Forestry Department. The total operational unit thus comprises almost 54,000 acres together with a certain amount of officially unoccupied grazing beyond the unfenced margins of the runs (Figure 2).

Physiographically, four distinctive types of country make up the Grasmere-Cora Lynn terrain (Figure 3). The Waimakariri here flows eastwards in a series of countless, ephemeral, and inconstant channels over a bed of course greywacke shingle sometimes more than a mile wide. Here and there are temporary islands and river banks stable enough to support a cover of tussock grasses, mat plants, and scrub. For the most part the steep walls of the glaciated trough rise sheer from the shingle-strewn river flats and climb steeply for thousands of feet; but elsewhere, sprawling shingle fans—perfectly smooth and symmetrical cones of rock debris—mark the entrance to tributary valleys. They partly mask the abrupt break of slope as they debouch out into the valley flat and divert the braided channels of the Waimakariri from one margin of its bed to the other. Finally, at higher elevation, and towering over river bed, shingle fans, and lower slopes alike, are the smooth grey fields of talus and fretted peaks of parent greywacke.

The runs embrace a maze of contrasting local climates. Each face has

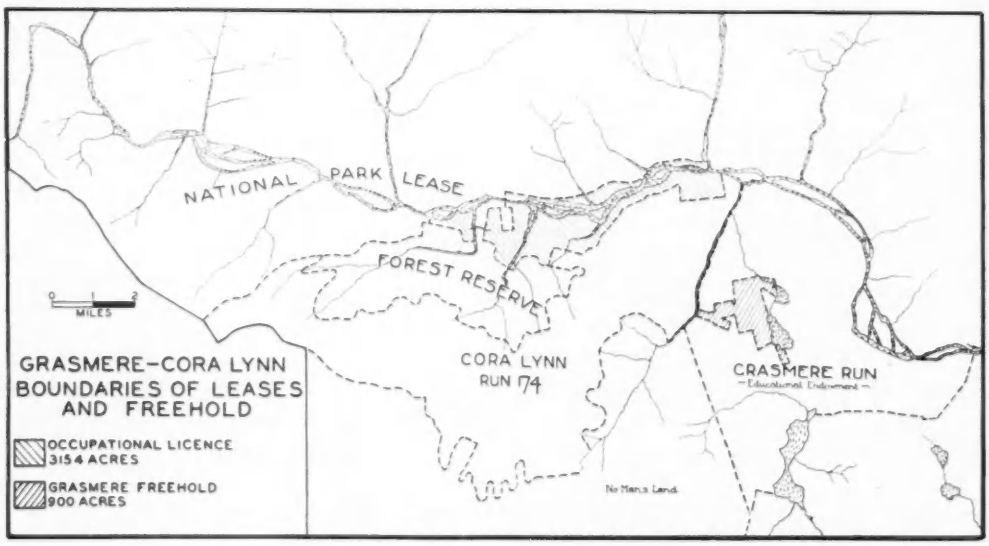


FIGURE 2.—Grasmere and Cora Lynn. Boundaries of Leases and Freeholds.

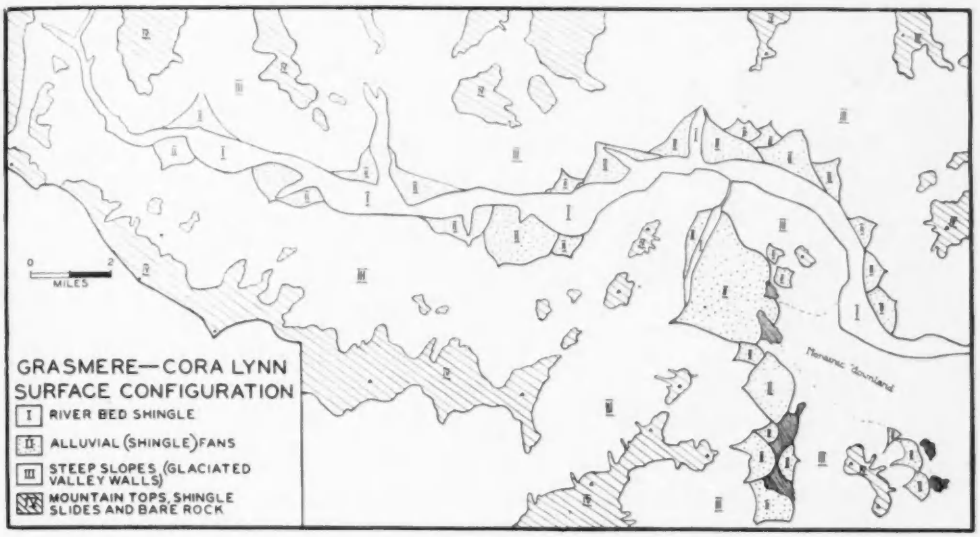


FIGURE 3.—Grasmere-Cora Lynn. Surface Configuration. (Closely lined areas are lakes.)

its own weather and climate depending on slope, aspect, elevation, and the amount of bare rock. Aspect is, indeed, a most important consideration as it is in all mountain climates. It is a factor with a most significant bearing on the nature of the plant cover, on pasture utilization and stocking practice and on the occurrence of soil wastage and pasture deterioration. It is especially so in view of the fact that the sunny faces (*adrèt* slopes) are exposed to the prevalent wind, which is frequently a hot, dry foehn. The more significant climatic traits are the frequency of frosts, the excessive daily range of temperature, the late spring, the erratic occurrence of nor'west rains, the strength and frequent dryness of the foehn, large amounts of sunshine, summer convectional rains (of local and limited distribution and high intensity), and the liability to winter snows from a westerly or southwesterly quarter. At the western margin of the Cora Lynn property, close under the divide and visited frequently by showers from across the ranges, precipitation averages 62.09 inches. It decreases eastwards at a rate of more than one inch per mile and at the Craigieburn homestead, just beyond the eastern boundary of the Grasmere run, amounts to only 35.81 inches.

These unusual climatic and edaphic elements produced an equally unusual series of vegetation associations—tussock steppe, southern beech forest, shrubland and minor river bed, rock and alpine associations (Figure 4). Today the tussock grassland is all-important—areally and economically. In 1850 it occupied the mountain slopes from the margins of the river bed shingle up to a general elevation of at least 3,000 feet except on certain shady faces and in damp gullies where it gave way to green-black islands of *Nothofagus cliffortioides* forest. (North of the Waimakariri, with heavier rainfall and southerly aspect the steep slopes are still occupied uninterruptedly by beech forest). The waving, dun-coloured steppe was composed of a number of grasses to all of which the bunched habit was common. The tussocks were of relatively low palatability to the introduced livestock. Unfortu-

nately the dominant tussock (*Festuca novae-zealandiæ*) was not as palatable as the less conspicuous grasses and this, together with the frequency in the association of shrubby and spiny plants, was responsible for the disastrous policy of ruthless and indiscriminate burning of the range. It is not even yet sufficiently realized that the principal function and value of the fescue tussock is to be found in its control of the microclimates at the surface of the ground and in the topsoil, and in its renewal of soil humus. The wealth of available literature overlooks both functions. Modern soil science may contribute much to the understanding of the ecology of the indigenous vegetation of the tussock grasslands of New Zealand and the problems of deterioration and depletion. The hundreds of acres of rotted and fire-blackened stumps on the Grasmere and Cora Lynn runs testify to the former occurrence of bush where induced tussock grassland now occurs, and the soil provides superficial evidence of a still wider distribution of forest where stumps have long disappeared.

The upper Waimakariri basin suffered a fate similar to that of the rest of the high country. It was burnt even prior to its settlement. Grasmere was taken up late in 1857 and Cora Lynn a little over two years later. Grasmere, with two other upper Waimakariri runs, was first leased by an Australian squatter, pioneer, and explorer, Joseph Hawdon. Hawdon sent his man ahead of him into the upper reaches of the Waimakariri and he burnt the country as he went, so that Hawdon could see from the Canterbury Plains the smoke of the fires. Even to those who have seen the steady, silent advance of a scarlet line of flame over the deteriorated tussock in calm weather or witnessed the noisy surge of fire through scrubby second growth, the destruction wrought by these original fires (fanned, perhaps, by nor'west winds and raging through the matted tussock growth of centuries and a virgin tangle of beech forest), is scarcely estimable. In accordance with high country custom, the Cora Lynn and Grasmere grazings have been burnt-over frequently since the late 1850's with the object of increasing palatability and at the expense of the vigour and

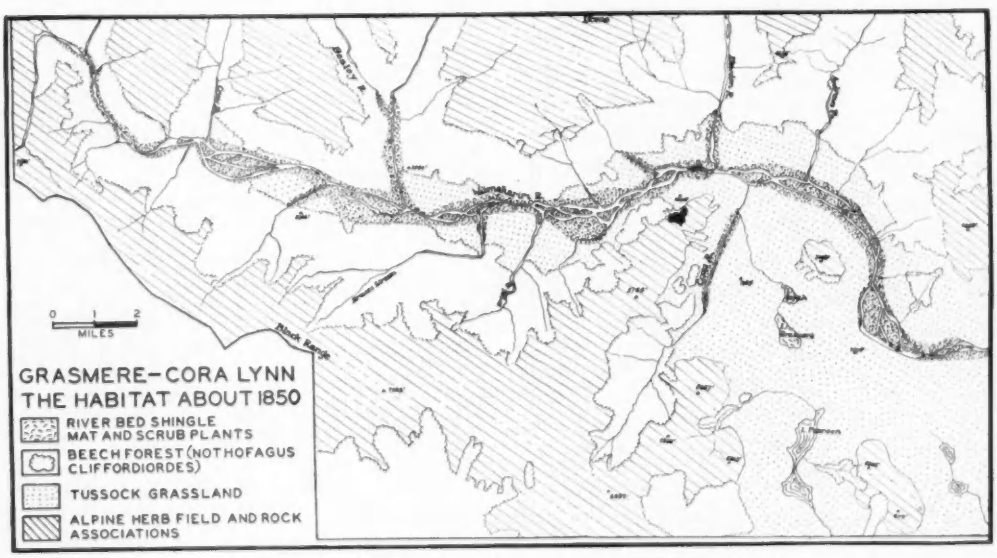


FIGURE 4.—Grasmere-Cora Lynn. The Habitat—1850.

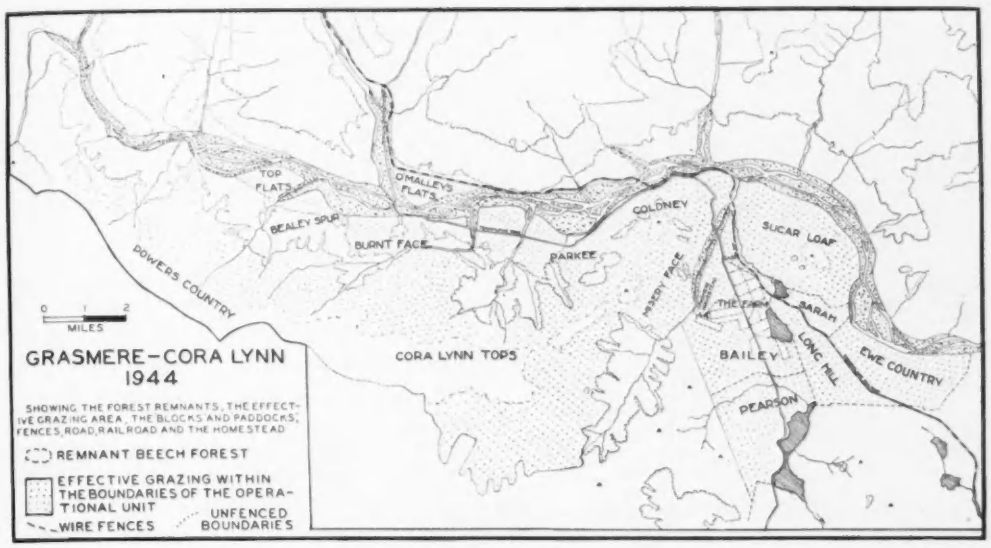


FIGURE 5.—Grasmere-Cora Lynn (1944) showing forest remnants, effective grazing area, blocks, paddocks, artificial fences, road, railroad, and homestead buildings.

variety of the herbage and the humus content of the topsoil.

Again in common with the tussock grasslands as a whole, the natural pastures of Grasmere and Cora Lynn have been seriously over-stocked. The close-grazing merino brought persistent and repeated aid to periodic burning in the destruction of the more palatable grasses and herbs and in the later deterioration of even the least palatable and (indigenously) most aggressive plants. Fortunately, the rabbit pest has never been serious in the upper Waimakariri and rodents have no significant part in the deterioration of the grazing. In this respect these runs are exceptional. Rabbits are very largely responsible for the greater deterioration and desert depletion to be found in Central Otago, the Mackenzie country and parts of Marlborough. The 1920 Commission found the rabbit to be the "most potent cause of all" and runholders blame the rabbit more than any other item. Introduced fauna has assisted not only deterioration but also the composition of the flora. Sheep have eaten out palatable indigenous species and assisted the spread of exotics. "English" grasses are found amidst the tussocks on most flats and lower slopes. On Grasmere, for example, some hundreds of acres are in sod-bound browntop (*Agrostis tenuis*) and sweet vernal (*Anthoxanthum adoratum*) has in recent years been displacing even browntop. These aliens have, in isolated cases, been surface-sown, but more frequently they were distributed by stock. Deer have been responsible for forest destruction and for the spread of weeds —noticeably sweetbriar (*Rosa rubiginosa*)—today the most serious of exotic weeds on both runs.

Maps (Figures 4 and 5) summarize the major vegetation changes of which evidence or record is available, while Table I provides a guide to the extent of overgrazing practiced in the past and to the declining carrying capacity of the deteriorated range.

RUN PRACTICE AND ECONOMY

Over 90 per cent of the 54,000 acre Grasmere-Cora Lynn unit is divided

TABLE I

SHEEP(1) GRAZED ON THE CORA LYNN AND GRASMERE LEASEHOLDS(2)

Year	*c. 1879*	*c. 1889*	*c. 1899*	*c. 1909*	*c. 1919*	*c. 1929*
Cora Lynn[3]	7,700	9,000(?)	7,500(?)	....	6,000	6,000
Grasmere	8,500	8,700	8,500	6,500	5,900	6,000(?)
Total	16,200	17,700	16,000	....	11,900	12,000

Year	*c. 1939*	*c. 1944*
Cora Lynn(3)	5,500	5,000
Grasmere	5,000	5,000
Total	10,500	10,000(?)

(1) Full grown sheep only are considered. Lambs do not graze heavily or otherwise depend directly on the pastures of the runs.

(2) For the sake of strict comparison, the capacity of the freehold "farm" is ignored after 1930. In the figures for years before 1930 it makes little effective difference to the total.

(3) The stock carried by the Forest and National Park reserves is included with the reduced acreage of the run after 1917. Records do not indicate clearly whether those stock numbers which are queried refer solely to Cora Lynn or whether they refer also to part of the other areas with which it has at various times been operated.

into, and utilized as, fifteen grazing "blocks" (Figure 5). Nine of these, ranging from 700 to 10,000 acres in size, comprise the Cora Lynn run, the Forest Reserve and the National Park lease; and six—none of more than 4,000 acres—form a large part of the Grasmere station. Both runs "lie well to the sun." The aspect of Cora Lynn is northerly and Grasmere faces northeast. The unit is thus favored with an extraordinarily high proportion of "sunny faces," that is, of "winter country" on which snow rarely lies for more than a few days and where the growing season for fodder plants is considerably lengthened by the longer duration and high angle of incidence of winter sunshine. "Shady faces," often frost-bound, sunless and snow-covered in winter, are few and small. They include the left bank slopes of the Cass River, the southern face of Sugar Loaf, and the National Park flats beyond the Waimakariri and in the shadow of the main range. The only blocks of pasture utilized in summer alone ("summer country") are the Cora Lynn Tops and Powers Country (Figure 5). In addition to the "blocks," there are one or two homestead and swamp "paddocks" on the Grasmere freehold, together with 300 acres of cultivated land. This latter is divided into ten "paddocks" and is known as "the farm." The operational center of the unit is the Grasmere homestead. (Few traces remain of the old, original Cora Lynn buildings.) The homestead comprises a nuclear group of buildings including the old limestone home of the owner, men's quarters, shearers' buildings, woolshed and store, sheep yards, implement sheds, cow bail, etc., largely hidden in a cluster of tall exotic trees. As the operational center of the present managerial unit, the homestead is not well situated. The Top Flats "block" of the Cora Lynn run is sixteen miles distant and this entails a long and weary driving of sheep after an arduous mustering of unfenced grazings. The "paddocks" are well fenced with wire; but many of the "blocks" have little or no artificial fencing. The edge of the bush, steep rocky inclines, and river courses prove sufficient even as boundary fences. High country sheep, bred on a property,

rarely stray from it. This is an especially characteristic trait of merino flocks.

The livestock on the station comprises in total some 11,000 sheep (plus lambs), four dairy cows, a few farm horses and hacks, a little under 100 beef cattle and teams of sheep dogs. The dairy cattle satisfy the milk, cream, and butter needs of the owner's family and his employees. The beef cattle—"run cattle"—are store Herefords, which graze the heavy tussock and swamp vegetation of the Grasmere section. The sheep are half-breds—merino-Romney and merino-Leicester—which though not as hardy as the merino, less catholic in diet, heavier of frame, and larger of stomach, are, nevertheless, suited to the country and all but the worst of the winter weather and they provide a fine wool of high count. The 5,000-odd ewes are the basis of the flock, while 3,000 heavy, hardy wethers with some hundreds of dry ewes graze the poorer, more broken country of higher elevation. The flock—both ewes and wethers—is renewed from the 3,000 hoggets carried each year. During the summer months the run also accommodates more than 3,500 lambs. The fleece of these mature half-bred sheep averages seven pounds of wool. In a normal year the run produces a "clip" of some 200 "bales"—80,000 lbs. by weight and £4,000 N.Z. ($12,750) by value. The return from the wool "clip" normally meets the operation expenses of the unit.

Table II shows the relative carrying capacity of the "blocks" and the "farm" and provides a summary of the seasonal distribution of the flock over the run (Figure 5). The carrying capacity of the unit is effectively determined by its carrying capacity during the winter months. On Grasmere-Cora Lynn this has been very noticeably raised as a result of the highly successful experimental production of exotic rotational pastures, root crops, and lucerne hay on the "farm." Table II shows to what extent the "farm" bolsters the capacity of the range and thereby illustrates (in conjunction with Table I) the extent of over-stocking in the earlier decades of settlement.

FIGURE 6.—The shingle bed of the Upper Waimakariri, tributary alluvial fan and the unoccupied National Park beyond. Notice the black carpet of southern beech forest and its abruptly defined lower margins. (Photo: H. H. Gallagher.)

The severity of the winter climate fixes the capacity of the runs through the year, and its duration conditions the time and the rhythm of all major operations. The station moves into action in October with the tardy arrival of spring, new grass, and lambs. It is noteworthy that new growth on most of Grasmere shows up at least a month earlier than on all but few parts of Cora Lynn with its much heavier precipitation, and that similar differences in the first appearance of spring growth are to be found even on the *adrèt* and *ubac* slopes of gently inclined (eight per cent slope) alluvial cones. The Ewe Country, Goldney and Parkee "blocks" provide the earliest growth and these, with the Top Flats are used as "maternity wards." The shearing shed with its eight stands is normally a hive of activity about Christmas. Shearing, wool classing, and baling are done by "migrant", temporary labor,

TABLE II

THE SEASONAL DISTRIBUTION OF SHEEP OVER THE RUN

Block	*Approx. Area (Acres)*	*Stock Carried*		*Period of Grazing (Months)*	*Approx. Annual Carrying Capacity in Terms of Full Grown Sheep per 100 Acres*(1)
		Number	*Kind*		
Top Flats	2,200	500	Ewes	9	17
O'Malley's Flat	1,300	500	Ewes	9	29
Bealey Spur	2,250	500	Wethers	6	11
Burnt Face	3,000	1,000	Wethers	9	24
Powers Country—	22,000	3,000	Wethers (2,500) and Dry Ewes (500)	3	4
Cora Lynn Tops—					
Parkee	3,400	1,700	Ewes	12	50
Goldney	5,000	900	Ewes	12	18
Misery Face	1,300	500	Ewes	9	28
Sugar Loaf	4,100	1,700	Wethers (1,300) and Ewes (400)	9	31
Sarah	450	300	Ewes (or Hoggets)	9	48
Ewe Country	3,200	1,300	Ewes (or Hoggets)	10	34
Long Hill	1,000	500	Ewes (or Hoggets)	10	42
Bailey	2,800	1,100	Hoggets	10	32
Pearson	1,500	700	Wethers	10	40
The "Farm"	330	1,700	Hoggets (1,000), Ewes (500) and Wethers (200)	12 (Hoggets for 6 months and remainder for 6 months)	287
Cora Lynn	38,600	5,000	.....	12	12
Grasmere (incl. the "Farm")	14,900	6,000	.....	12	43
Operational Unit	c. 54,000	c. 11,000	.....	12	c. 20

(1)Carrying capacities are adjusted to fit the variations in the "Period of Grazing" column. Thus, to enable strict comparison to be made between the capacity for example the Parkee, Sarah, and Bealey Spur "blocks," the figures for Sarah and Bealey Spur have been reduced to a 12 month equivalent (that is, by one-fourth and one-half respectively).

Though the shed is equipped with machines driven by water wheel or petrol engine, they are employed only for crutching and hand blades are used for the major shearing. Machines clip too close to the skin and runholders have found, to their cost, that closely-shorn ewes succumb easily in unseasonable cold spells.

After shearing, the wethers and dry ewes are driven to the "summer country"—to Powers Country and Cora Lynn Tops. These are a lofty wilderness of rock, talus, bush relics, subalpine scrub, and herbfield. (Some 16,700 acres on the original Cora Lynn run were classified as "barren.") Ewes and lambs now occupy the "blocks" of intermediate elevation and the best of the "winter country" is briefly spelled. In the March-April period there is a general muster of the entire flock. Ewes and lambs are brought in and the lambs are drafted and weaned. The ewe flock and the wethers are culled. Surplus stock is drawn off and despatched "down country" either to meat-freezing works (if fat), or to arable fattening farms on the Canterbury Plains (if in store condition). The remainder of the sheep are dipped, and when the rams are put to the ewes in May, the "winter country" and the "farm" are stocked to capacity (consistent with conservational husbandry).

The "farm" merits separate attention. It is rarely the practice on high country tussock runs to employ the plough with the object of raising the volume of winter feed and the sheep carrying capacity of the holdings. Short leases (and no assurance of renewal) have no doubt prevented graziers from attempting such hazardous improve-

ments in the past, and on some merino runs the absence of land with sufficiently gentle slopes for arable cultivation precludes the use of the plough. Short growing seasons and inaccessibility (which raises the cost of freighting artificial fertilizers) also militate against tillage agriculture and the establishment of exotic pastures. On many back country stations, however, it has long been the practice to grow oats for the hacks, pack horses, and team. Oats were grown on Grasmere (and again on Cora Lynn, when it was a separate unit) not only to feed the farm horses but to provide chaff for coach horses traveling the West Coast road. It is more usual to winter stock "down country" on agistment than it is to grow roots and other fodder. Turnip crops, however, are not uncommon on the runs, despite the brevity of the growing season for roots and the fact that the pure-bred merino flocks have an aversion for artificial feeding.

The Grasmere-Cora Lynn "farm" is thus rather exceptional. The area cultivated by previous runholders was occupied by sod-bound browntop when the present owner took control. Three hundred acres of this reverted pasture, carrying some 150 sheep, have been cultivated anew. A fertility-building rotation of roots (or alfalfa) and temporary grass and clovers has been instituted to replace the old sporadic, fertility-depleting cropping with oats and roots. The ten paddocks are ploughed out of grass in succession and, after yielding a crop of turnips, are sown down to a mixture of ryegrass (*Lolium perenne*), crested dogstall (*Cynosurus cristatus*), cocksfoot (*Dactylis glomerata*), and certified white clover. Pasture establishment is assisted by heavy liming and by topdressing with superphosphate. The pasture seed is spring sown. With autumn seeding, the young grass and clover plants are lifted out of the soil by severe nightly frosts during the following winter. In spring, however, the foehn wind is at its maximum strength and frequency, and there is always a danger of "blowing"—wind erosion—from the finely-worked surface of the paddock. The wealth of feed provided by turnips and exotic pasture supports a dense livestock population, and the heavy animal manuring of the soil assists the clover (and alfalfa) in building up the fertility of the light and humus-deficient alluvial soils. A "paddock" of 24 acres has been in alfalfa for four years. The stand is still good. It yields two hay crops a year amounting to 2,500 bales (70 tons) for winter feed. The present methods have raised the carrying capacity of the 300 acres of the "farm" from 150 to over 1,000. By providing winter grazing and hay, they have lifted the winter carrying capacity of the run and eased the pressure on the native winter pastures. With the grazing provided by exotic pastures, it is now possible to fatten cull ewes and wethers in the late summer and the "farm" carries over 1,000 hoggets through the winter with a much lower death-rate than is the case on the range. The hoggets are, moreover, in far better condition at shearing time

FIGURE 7.—Sprawling shingle fans, glaciated profiles, steep mountain walls and rocky, snow-capped summits. Cass Basin-Grasmere leasehold. (Photo: H. M. Sweney.)

FIGURE 8.—Deteriorated tussock flats. Notice the sod-bound low cover of poor exotic grasses. The "farm" was in this condition until a new arable-pasture policy was adopted. Near the Cass railroad station. (Photo: H. M. Sweney.)

and each produces a fleece of two pounds extra weight as a result of its better treatment.

THE PROBLEMS OF THE RUN

Grasmere-Cora Lynn has fewer problems than the vast majority of high country sheep runs; and the problems present are individually less pressing than is usually the case. Winter snowfall is less than on runs exposed to the west and southwest and the thaw is not usually long delayed. The winter feed of the range is supplemented by the "farm." Whilst, periodically, some high country flocks are decimated in winter, the average death-rate on Grasmere-Cora Lynn averages between seven per cent and 10 per cent, and is not so much due to winter snows, as to the unfenced railroad, the erratic water courses, and unseasonable cold spells following shearing.

Despite the feed produced by the "farm," the run carries fewer sheep now than in the past (Tables I and II). This is in part to be explained by the change from a merino to a half-bred flock, but is in greater measure due to the substitution, after 1930, of an enlightened policy of wise and conservational grazing for one of overstocking. The extent and nature of the deterioration of the natural pastures of the South Island has been appreciated for many years. Yet the causes are still in operation on many runs and deterioration proceeds apace. In the drier areas, it has already reached the stage of utter depletion. The enlightened policy operative on Grasmere-Cora Lynn involves—in addition to lighter stocking—an almost complete ban on tussock burning. It is also favored by the enviable paucity of rabbits. Deterioration has, as a result, been arrested and the nature of the problem has shifted. The tussocks now have renewed vitality and are often to be seen colonizing bare or depleted areas. The most highly prized of the indigenous grasses—the palatable blue grass (*Agropyron scabrum*)—is very frequent. (The fact that it was "exceedingly rare" in 1915 prompted the suggestion then that it was probably absent from the indigenous association in this vicinity). The renewed vigour of the tussocks and of "bottom feed" are not the only results of the freedom from fire and from excessive grazing. The current fire and grazing policies have also encouraged the

spread of forest and shrubby growth. Not only are beech forest relics regenerating around their margins but the range itself is being rapidly invaded by native shrubs and herbs—*Cassinia spp.*, *Discaria*, *Corokia*, *Leptospermum scoparium* (on shady faces and damp sour soils), and *Aciphylla*. The exotics, broom, gorse, and especially sweetbriar, are also very aggressive. In many areas some combination of a number of these shrubs occupy very appreciable areas of the range and detract from its grazing value. The only burns today on Grasmere-Cora Lynn are employed in an effort to maintain pasture at the expense of volunteer shrubland. The range is burned only when the fires can be controlled. Fires are lighted preferably on calm days. At most there must be but a slight breeze and then the fire is lighted into the wind. Only shady faces are burned. Fires are restricted to late winter and early spring and are not lighted until late afternoon so that should there be an unexpected and dangerous change in the strength or direction of the wind, moisture and frost after sunset are sufficient to damp them out. These restricted and controlled fires are sufficient temporarily to subdue the volunteer and successional indigenous shrubs; but sweetbriar, its seeds spread by birds, deer, and sheep, is not readily destroyed by burning and is today the most serious and most widely scattered weed on the range in this locality. Under current economic conditions, its control is an involved and unsolved problem.

Of the animal pests, deer are here of greatest significance. (In the high country as a whole, rabbits present a much more pressing problem.) Deer are responsible for eating out the undergrowth and beech saplings in the outliers of forest still extant. They ringbark mature trees and cut tracks through the forest and alpine shrubland which, during heavy and high-intensity convectional rains, develop into incipient gullies. They thus expose the much jointed greywacke to frost-prying and give rise to new and induced talus creep. Travelling at night, the deer come down from the headwaters of the Cass River to the Grasmere "farm" and graze in herds of twenty or more on the turnip

FIGURE 9.—The fenced off "paddocks" of the Grasmere farm in high quality exotic pasture grasses lucerne and root crops. Notice the profile of the large alluvial cone beyond. (Photo: H. M. Sweney.)

crop. Moreover, they destroy young shelter belts. A trial planting of *Pinus bonderosa* as a windbreak on the "farm" was badly mutilated by deer. Any fence of less than eight feet in height does not deter them. Under present conditions fencing of any sort is out of the question because of the scarcity of materials, the shortage of labour, or the prohibitive cost. For similar reasons, the work of deer culling over the mountains is much reduced below pre-war standards.

Fencing is itself a major problem on the South Island runs, as it is also in many New Zealand regions where the farm economy is, by comparison, intensive. The frequent lack of boundary fences is not a real handicap where the grazing run borders upon unoccupied and forested tracts. Inadequate subdividing of the pasture "blocks", however, is a serious matter and frequently prevents effective conservation and wise utilization of the range no matter how enlightened the policy of the runholder. The Grasmere-Cora Lynn "blocks" average over 4,000 acres in extent. Such enormous enclosures are not exceptional. This is mountainous country of intense relief and ever-changing slope and aspect. Despite the favourable aspect of the run as a whole, the larger "blocks" embrace both sunny and shady faces. Stock, in its search for food, favours the sunny slopes. Sunny faces are at once and the same time drier, windier, and subject to the greatest daily ranges of temperature (usually involving a twice daily transit of freezing point). They were also less densely vegetated under undisturbed conditions and are today more heavily grazed and subject to more serious deterioration. Here the plant cover is sparse and soil erosion rampant. On Grasmere-Cora Lynn such slopes are not burned and stocking of the "blocks" is light. Yet more adequate fencing appears to be imperative in order to prevent stock from concentrating on the sunny faces and avoiding the sunless *ubac* slopes, to ensure rotational grazing of the range, and to conserve feed on snow-free areas for winter use. It is also a prerequisite if pasture deterioration and soil wastage are to be arrested.

FIGURE 10.—The Grasmere homestead and some of the station buildings (others are out of sight.) Around the yards and buildings a variety of exotic trees—North American and European conifers and European deciduous species—are making good growth. Beyond deforested slopes formerly in *Nothofagus*. (Photo: H. M. Sweney.)

FIGURE 11.—Sunny faces and basin flats on the Grasmere section of the unit. Notice the bare exposure of soil between isolated tussocks in the foreground. The black patches are the product of controlled, small late-afternoon fires lighted to destroy the growth of manuka in a low, damp (often shady) position. (Photo: H. H. Gallagher.)

Of the immediate problems, the cause of which is implicit in the policy and practice of the sheepmen on the runs, the most formidable is soil erosion. It has become more fundamental than that of range deterioration, now long appreciated. To solve one is to solve the other; but soil erosion is so serious in the South Island tussock high country that it now warrants prior consideration for it might prove necessary to withhold leases and withdraw the range from pastoral use. New uses and other patterns of occupance might become imperative should it be found advisable to substitute a completely alien vegetation for the present diminishing cover.

Scientific and progressive management are not sufficient to overcome the wider external problems which, with few exceptions, affect the primary industries of New Zealand. These problems are economic and political. Even in periods of peace, New Zealand is undersupplied with farm labor—indeed New Zealand is sadly underpopulated. In recent years manufacturing industries with much official encouragement have attracted labour from the land. The isolated back country areas have felt this withdrawal of manpower more particularly. The war has very noticeably accentuated these trends, and it has, in addition, removed youthful and experienced farm personnel for service in the armed forces.

In the heyday of the high country runs, each group of homestead buildings housed a sizeable, though isolated community. It comprised the owner and his family, the manager, shepherds, permanent musterers, ploughman, rouseabout, gardener, cook, and cowboy, and, during cramped and busy summer months, temporary gangs of musterers and shearers. In 1944, the combined runs, Grasmere and Cora Lynn, employ three persons permanently—owner-manager, shepherd, and cowboy. As a result the station suffers from inade-

quate care. The more isolated "blocks"—on Cora Lynn—are, of necessity, neglected. The present operator claims that Grasmere and Cora Lynn could be farmed successfully as separate and economic operational units. For efficient management Grasmere would require the labour of at least five permanent employees despite the mechanization of the "farm." Cora Lynn would provide work for a manager, tractor-driver, shepherd, and cowboy together with seasonal musterers and shearers. Under such conditions of adequate labour, carrying capacity could be increased by more than 1,000 sheep; stock losses would be reduced and the pastures more successfully conserved. There is land on the Cora Lynn run—river flat adjacent to the main highway—suitable for the duplication of the Grasmere "farm" and the heavier rainfall there should make the establishment of rotational pastures of superior grasses and clovers even more successful. New fences could be built and shelter belts erected. There is little protection for stock on the range; and crops and pastures—both "natural" and introduced—would benefit from more and better shelter.

The high country has had little official attention for many years. Its problems have had superficial examination, but the findings of private and public investigation have not as yet been followed by official assistance or planning. The Government's policy has been vacillating and quite inadequate to the many problems presented by this national endowment, for the administration of which the government itself is largely responsible. The runholders occupy a large area—it amounts to almost a third of the occupied land in the South Island—but they are disproportionately small in numbers. Disproportionately small, too, is the voting power of the high country.

THE FUTURE OF THE HIGH COUNTRY AND THE RUNS

The South Island tussock high country produces wool—and little else. At the present moment it produces *relatively* little food. If it did, its future would be less in doubt for, by its acceptance of the recommendations of the United Nations Conference on Food and Agriculture, New Zealand is committed to maximize its output of food and to undertake the conservation of its soil and other resources necessary to that task. The continuance of the current economy is bound up above all with two doubtful factors: the ability of fine wools to compete with synthetic substitutes and the success or otherwise of efforts to arrest the deterioration of the tussock grasslands and the wastage of the thin mountain soils on which any restoration of the former carrying capacity must depend. Assuming a continuation of the present demand for wool, then it is essential that the recently established New Zealand Soil Conservation and Rivers Control Council bring early assistance to the sheepmen. There is an

FIGURE 12.—Rampant soil erosion. Both sides of the Cass River Valley had originally a continuous cover of beech forest (as towards the head of the valley even today). The bush was fired (in places as recently as 1917) and tussock induced (foreground). On the *adret* slope opposite, although charred logs litter the smooth grassy parts, the greater portion of the slope is gullied deep, and exposed greywacke (torn asunder by frost) extends in moving debris slides from the summit to the foot of the slope. (Photo: K. B. Cumberland.)

enormous amount of experimental research to be carried out if the present economy is to be made permanent in those parts of the high country where the soil is now bare of vegetation and exposed to the ravages of a terrain and climate alike conducive to rapid erosion. As yet, there has been little investigation, for example, of the possibilities of farm forestry under the severe frosty winter conditions of the South Island back country. Partial afforestation, to provide shelter for stock and grasses, to conserve moisture, to retard run-off, and to protect eroding soils, may well be a sufficient and satisfactory solution of many difficulties. It has not yet been demonstrated, however, what quick-growing, exotic trees are best suited to this mountain habitat. To date, the question of revegetating the range with fodder plants has been interpreted solely as a problem of restoring the original cover. But remembering that the indigenous grasses evolved in the complete absence of grazing animals, it is surprising that a search has not been made of the steppe and mountain grasslands of the rest of the world for grasses (developed in the presence of livestock), which might prove a suitable source of fodder and an adequate protection for the soils. It may be that even the tussocks themselves could be effectively replaced. In any case, there is room for experiment with potential "bottom grasses."

It can be argued that the present economic products of the back country do not justify the damage that is being

FIGURE 13.—Deforested slopes, cultivated flats, the cluster of homestead buildings amidst upright poplars and exotic pines together with ample evidence of the vigour of second growth invasion. The dark roche moutonne to the left of the homestead is covered with broom, gorse, and matagowne and is being colonised by native beech and exotic pines. (Photo: J. L. Hewland.)

done. If investigations can show that, with modification of administration, practice, and economy, the runs can still produce wool and meat economically, then the pastoralist should remain on the runs. If effective conservation and continued grazing are demonstrated to be incompatible, new uses must be found for this high country terrain. But it must not be forgotten that the ever-present danger from fire will make it difficult and costly, if not impossible, to preserve the mountain range in heavy, regenerated tussock and dense volunteer scrub when livestock is withdrawn.

There is, however, one change in farm practice and economy which seems imminent. That is the wider use of cattle in the control of the rank tussock and shrubby growth hitherto burned. Cattle are today rare on the range. Yet farmers on the Canterbury Plains—soon to be furnished with irrigation facilities and the opportunity of carrying more stock—find the available supply of store cattle already quite inadequate. The introduction of beef cattle, as a method of controlling pasture feed on the range, requires, however, more adequate fencing. Otherwise losses on the more rocky and precipitous "blocks" would be great. It also requires a considerable reduction of sheep population.

Should the grazing of wool sheep and beef cattle prove uneconomic in future, or should it be found necessary to prohibit the grazing of the mountain grasslands in the interest of soil and water conservation, protective afforestation appears to be the only significant use to which the land might be devoted. The creation of new catchment forests of exotic trees and the regeneration of southern beech forest would both enhance the tourist attractions of the mountains and be a guarantee of greater permanence for the only other use to which the high country is now put—the generation of hydro-electric power. The fire hazards would probably be less if native—even exotic—trees were ultimately to replace tussock grasses.

CONCLUSION

Grasmere-Cora Lynn is not in every way representative of the high country. Management, for example, is more enlightened than is usually the case; rabbits present no problem; deterioration has been largely arrested and the "farm" is a quite exceptional experiment. This detailed, *topographic* study of the habitat and practice of one operational unit has, however, broader, *chorographic* implications. The South Island tussock high country is a geographic region of clear-cut and compelling personality. It occupies slightly over 12 per cent of the total area of the Dominion (Figure 1). Its physical setting, its sparse and "extensive" pastoral occupance, and its peculiar problems, lend it distinction and together clearly differentiate it from adjacent regions, and the Grasmere-Cora Lynn run provides admirable illustration of the characteristic traits of the region of which its 54,000 acres form but a fragment.

DEVELOPMENT OF THE LAGUNA REGION

Lorene A. Garloch

THE Laguna Cotton Region is not only the oldest cotton region of Mexico but also the most important, producing 51 per cent of the Mexican cotton. A large basin in north central Mexico, the lowest part being 3,700 feet above the sea, forms the Laguna Region. It extends over 1,250,000 acres of the Bolson de Mayran which is a part of that immense region known as the Bolson de Mapimi.

The municipalities of Torreón, San Pedro, Matamoros, and Viesca in the state of Coahuila and Gomez Palacio, Lerdo and Mapimi in Durango comprise the Laguna Region. The inhabitants of these municipalities numbered 263,157 in 1940. The population density thus averaged 135 per square mile. About 70 per cent of this population is in Coahuila and the remaining 30 per cent in Durango. The census figure for 1940 shows a decided increase, for in 1924, there were only 175,000 inhabitants in the entire Region. Of Mexico's total population, 25 per cent live in communities with less than 300 inhabitants. However, in Laguna, the percentage of rural population is much higher. Approximately 46 per cent of the people are rural, the remaining. 54 per cent being distributed among six cities and numerous towns.

There exists in the Laguna Region an excess population in proportion to the irrigated as well as to the distributed lands. The great overpopulation which exists today is due for the most part to the fact that the agrarian distribution was made in 1936 during the months of October, November, and December, just at the time the picking was completed. The picking season, August to October, raised the population from 17,000 to 36,000 peasants. During this period, a large mass of peasants came to live in the Region. In exceptionally good years, they earned enough to take care of their needs and saved a little to take back to their place of origin but the good years were rare. This overpopulation has created one of the most serious problems of the Republic. Numerous measures are being taken towards solving this difficulty.

Military measures, plagues, droughts, and famines all but completely wiped out the indigenous population of Laguna Few of the inhabitants are direct successors of the Indians who were living peaceably in the Region when the conquerors came. There is no trace, ethnographic nor linguistic, of any Indian tribe. The racial type predominating is Spanish-speaking Mestizo.

When the Spanish conquistadors commenced to colonize Laguna, it was inhabited by a number of tribes whose manners and customs were gentle and peaceful and who were called generically "Irritilas" or "Laguneros." They lived by fishing in the Nazas and the Aguanaval rivers and in the lagoons of Mayran and Viesca, by planting on the banks of the rivers, and by hunting or gathering wild products of the forests. They held their lands as communal property and worked them collectively. Little difficulty was had in protecting their lands since mountains and arid plateaus shut out the poorer tribes to the north. They were unprepared to-

resist when a Spanish noble, the Marquis of Aguayo, with the aid of a small party seized the Region and claimed it as his own. Under the Spanish landlords, the conditions of the Indians changed from free agricultural tribesmen to feudal serfs. At the same time, their character changed and they became warlike. When defeated, the natives took refuge in the hills and continued to attack their oppressors. Due to a combination of dissipation, firearms, liquor, and disease brought by the Spanish, the native population was decimated. In 1598, at the time of the first colonial settlement, 16,000 to 20,000 Indians were in the Region. In 1668, less than 100 years later, as a direct or indirect result of Spanish colonization, the Irritilas were reduced to eight families.

The Laguna Region belonged successively to the descendants of Francisco de Urdiñola, to the Marquis of Aguayo and to José Miguel Sanchez Navarro who sold the Region immediately to Leonardo Zuloago and Juan Ignacio Jiménez for 80,000 pesos. The estate of the Marquis of Aguayo formed the greatest latifundio of which we have heard as being the property of one man. These lands were coveted because of the rich vegetation which made cattle grazing profitable. As a result, this locality became the seat of the great cattle grazing haciendas of noblemen, agriculture being practiced in only a few places on the banks of rivers. In 1828, all of the haciendas and ranches in the Region contained only 500 people; Aguayo made real colonization impossible. His cattle replaced the 20,000 peaceful Iritilas who had lived happily on the plains between the lagoons and rivers. The cultivating and irrigating systems were very poor until the middle of the last century. In 1840, Zuloago and Jiménez, successors to Aguayo, began cultivation on the Nazas and constructed the first dam, the Calabazas in 1849, marking the beginning of the agricultural prosperity of the Region. About this time, the use of irrigated lowlands for commercial wheat farming was started; for many years this was Mexico's chief wheat district.

The widow of Zuloaga maintained the estate intact until she decided to sell the land to liquidate certain debts. The heirs of Jiménez did likewise a little later. The new owners, British and German in part, were connected with commercial firms. Some of the large estates were sold to smaller owners. At the time of the expropriation of land in 1936, 70 per cent of the land was foreign owned, of which 40 per cent was held by two British companies. The Region presented the usual picture of a plantation economy: absentee

FIGURE 1.—An Ejidatario from the Ejido of San Ramon.

FIGURE 2.—The average home of an ejidatario, Zaragoza.

landlordism, hired superintendents, company stores, company currency, credit extended in such a manner as to enslave the peon, utter lack of sanitation, paucity of education, and other detrimental human relations.

Of the total territory of Mexico, not more than eight per cent is, by nature, suitable for agriculture due to the physiography of the country and to the peculiar climatic conditions. It is therefore believed that if the Mexican people are to live a normal economic life, the big estates must be divided into small farms.

In 1910, the year of the Mexican Revolution, two per cent of the population owned about 70 per cent of the land; conversely, in some districts, 98 per cent of the heads of families were landless. Correction of the abuses of the Latifundio system was one of the aims that unified the Mexican people in the political upheaval of 1910, inspiring them to carry it through to successful conclusions. The Constitution of 1917 adopted the principles of land reform and incorporated them in Article 27, the legal basis of all subsequent agrarian legislation. The present land reform is directed toward the breaking up of the large estates and the redistribution of land in order that the proportional shares will eventually be held by those who will work the land.

The Revolution of 1910 gave the land back to the peasants by breaking up large estates; however in Laguna, owners by bribery and intimidation kept their vast holdings. From 1927–33, the introduction of modern agricultural machinery—tractors, thrashing machines, etc.—with the object of reducing the cost of production, increased the antagonism between employers and workers. Strikes became more numerous. Nothing important was done about the distribution of land in Laguna until 1934, seventeen years after the Constitution of 1917 had incorporated the agrarian slogan, "Land and liberty," into the fundamental law of the country. Then to siphon off their discontented peons, the hacienda owners raised two and a half million pesos, purchased marginal land on the outskirts of the Region, farthest from the water supply, and invited President Rodriguez to give it to the peasants who wanted land. This was done in two presidential decrees on October 15, 1934. The landholders then rested more easily until Cardenas became President.

In 1936, the cotton pickers on one hundred and four plantations struck. Cardenas intervened on behalf of organized labor and ordered the immediate distribution of the cotton lands. In October, two hundred government engineers were rushed to Laguna to survey the plantations and to plan collective exploitation of the irrigated zone. Many landowners let the irrigation water run wild, fields were flooded, wells dismantled, and mobile equipment sold abroad while herds of mules were driven across the frontier. The government retaliated with a 200-peso export tax on mules, whereupon landowners drove their mules into the desert hills leaving them to die rather than to sell them to the peasants. For forty days, Cardenas camped in Laguna, supervising the organization of the giant experiment. Millions of pesos were paid to the

planters to compensate them for wells, livestock and growing crops turned over to the peasant coöperatives.

Of all the land distribution projects carried on in Mexico in the last few years, that of Laguna is most significant. Population multiplied rapidly and only a small proportion of the population could be profitably employed all year on estates. Since it is impossible to earn a livelihood in Laguna without access to water, the latter being monopolized by landowners, the seasonal worker was reduced to beggary or starvation part of the year and the unemployed reduced to that level all of the year. There were constant uprisings put down each time with great cruelty. Reforms in Laguna have changed the lives of 200,000 people or over 36,000 peasants in 296 communities. This was more than double the farming population ordinarily engaged in the same area. These 36,000 peasants received 287,035 acres of irrigated lands and 318,180 acres of non-irrigated lands usable as pasture.

Each owner was allowed to retain 375 acres of land of his choice and most of them chose lands surrounding their homes and barns. They were offered forty-year agrarian bonds which some refused. The value of the land was determined by consulting the records of what the owners themselves had said the land was worth. The richest fifty of Laguna, about 112,000 acres of irrigated land, is still in private hands.

FIGURE 3.—Weighing of cotton, warehouses in background.

The cry of communism, heard after the distribution of land, can be answered by three points. (a) The ejido system was used by the Indians before the arrival of Cortez. (b) Zapata began land division in 1910 before the Russian Revolution. (c) Division of estates was made constitutional in Mexico in the same year that the Russian Revolution began. Credit, technique, organization, and discipline in work—everything that served as a basis for production in great properties—has been retained and even bettered by ejidal production. One element alone has been done away with—private gain.

In Laguna, because of the need for irrigation and the type of crops and equipment used, small farms could not be worked profitably. Therefore, large collective farms were organized on expropriated land modeled on the ancient system of Indian land holdings. These small farms are known as ejidos in Mexico. The National Bank of Ejidal Credit was established in Torreón to advance money to the ejidos and to give them advice and assistance. Every ejido is a self-governing democratic community whose lands are worked in common for both mutual and individual benefit. Profits are not shared among communities so each ejido must stand on its own feet; there is a noticeable difference in efficiency and earning power among them. Each ejido elects an administrative committee of six and a vigilance committee. There is also a president of the society, a warehouseman and a mechanic. More important is the work chief who is directly elected by the peasants. His main task is to direct field work and to see that the yearly plan of operation, developed by the Ejidal Bank, is carried out. He serves as transmission belt between the

Torreón planning agency and the peasant assemblies.

The ejidos vary considerably in size and in the number of members, depending chiefly upon the original distribution of the population among the plantations and upon the quality of the land granted. The total area cultivated by the ejidos is about 300,000 acres. At the time of the Cardenas distribution, each peasant received ten acres of irrigated land and twenty acres of undeveloped land. In many communities, neatly plastered adobe houses, small and simple but with windows and concrete floors, have already begun to replace foul, unsightly shacks and caves in which the peasants formerly lived. Reed and mud huts, caves in the river bank, and adobe shacks, in many cases totally unfit for human habitation, helped to increase the mortality rates. After the distribution of profits, the peasants buy furniture, radios, sewing machines, clothes, and even start improvements on adobe huts. Beds have been the most popular purchase, replacing the traditional petate. Regional market statistics show that the peasants are eating corn, wheat, and beans as their chief foods. Government engineers are now working to provide safe drinking water in all parts of Laguna.

In the old days, peasants earned 75 centavos to 2.25 pesos daily, depending upon the season, the cotton market and the demand for field labor. Today, there are standard daily wages ranging from 1.50 pesos for common labor to six pesos for mechanics, tractor operators and other skilled workers. During the picking season, piece rates are paid. When the crop is harvested, all the expenses including the standard wages are deducted, leaving the remaining sum or profit to be divided among the ejidatarios on the basis of the number of days worked rather than on the type

FIGURE 4.—Warehouses belonging to the Ejidal Bank.

of work performed. The average earnings of the ejidatario are, therefore, over two pesos per day in addition to the standard 1.50 pesos, making a total of almost four pesos per day. At the end of the first year, the most industrious man on an ejido received 1,450 pesos profit for the year, and the lowest paid worker received 278 pesos. Previous to the agrarian reform, such profits had always been spent abroad. As Cardenas explained, "Mexico's collective agriculture was born in Laguna. In the past, groups of peasants were given worthless parcels of land without tools, equipment, credit, or organization. . . . The ejido so conceived would have resulted only in disillusionment and in giving the landlords yet another excuse to reduce to a still more wretched level, wages that are already wretched enough."

The present agrarian movement in breaking up large estates and allotting land to former tenants, is influencing the production of cotton to a marked extent. The cotton production is somewhat disorganized; the landlords who supplied necessary supervision, extended credit and sold provisions to cotton growers are noticeably missing. Many growers who have been tenants for years and who are now owners are unable to adapt themselves to changed conditions and crop averages have therefore declined. (Table IV in "Cotton in

the Economy of Mexico" showed a comparison between the yield under the ejido system and that under the plantation type of agriculture. ECON. GEOG., January, 1944.) The reduced production on the part of the communal farms may be attributed to two principal factors which eventually may be overcome, (a) lack of sufficient government credit for the necessary equipment and supplies, (b) inefficiency on the part of a large number of laborers due to lack of close supervision. Six-year planners say that there is more to the plan than marked figures. They regard a thing like Laguna primarily as a school beyond "profit and loss economy." All financiers granted that such a profound economic experiment could not be judged after one year's operation, but rather that its result could only be appraised after ten years of operation. If the financial success of the project is sometimes debated, the improvement in social conditions is undeniable. Educational facilities, sanitation, first aid stations, and the morale of the laboring class have been decidedly improved.

Industries are increasing yearly in this Region. The largest soap factory in the country is located in Gomez Palacio. This soap works manufactures soap, cotton seed oil, and cake from the products of the Region. There are important cotton, flour, and iron mills in Torreón as well as many other minor factories. Much of the area adjoining the Laguna Region is not a fertile agricultural region. A large number of people in this district do not produce sufficient food crops to feed themselves but depend upon the increasing mining industry for their income. Several very important mining towns are located near Torreón, Durango being one of the principal mining states in the Republic. Many important towns in Coahuila have been developed because of deposits of silver, gold, copper, lead, and iron.

A local plexus of railroads cares for the needs of the Laguna Basin. It is connected with outside sections by railroads running south to the Mexican Plateau, east to Monterrey, northwest to El Paso and southwest to Durango. Torreón, the principal city, is located on the main line of the National railways of Mexico at a distance of 518 miles from Juarez and 706 miles from the city of Mexico. Torreón is located at an elevation of 4,000 feet with a population of 76,631. This city is a railroad center of first importance in the northern part of the Republic. It is the concentrating and distributing center of major importance in the production of Laguna cotton. There are two important suburbs—Gomez Palacio in the northwest and Ciudad Lerdo in the west. These three cities form the nucleus of the whole group of

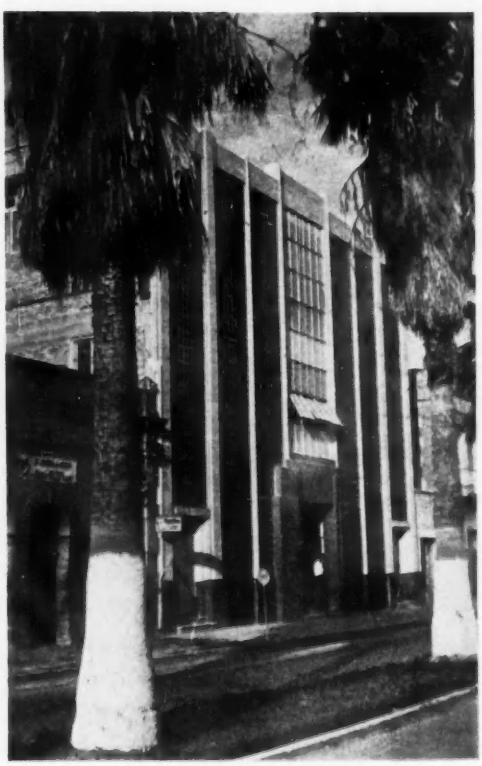


FIGURE 5.—Ejidal Bank, Torreón, Coahuila.

Laguna cities. These cities thrive on trade in cotton, wheat, imported foodstuffs, and the products of the neighboring mines. Gomez Palacio is an industrial center with a population of over 25,226 while Ciudad Lerdo is a busy commercial town with a population of over 9,000.

Two main railroads cross at Torreón, one from Juarez to Mexico passing through Torreón and Gomez Palacio and the other from Eagle Pass to Durango. The irrigated area is traversed by many branch lines such as those which go from Gomez Palacio to Monterrey and Tampico, from Torreón to Tlahualilo, from Torreón to Asserraderos, from San Pedro to Algodonales, and lastly, one which goes from Estacion Cadena on the Mexico-Juarez line to a point called Dinamita. The railroads of Coahuila rank first in mileage among the states of Mexico, there being over 1800 miles of railroads in the state.

A regular system of roads and highways completes the network of communications in Laguna and facilitates the distribution of the products between the cotton zones and the consumer centers. The most important highways are those which extend east and west. One highway goes from Torreón to Durango and the other from Saltilo to Torreón. A third, when completed, will run north and south connecting Juarez with Mexico. Coahuila has many sand and dirt roads with few grades. Around Torreón, the natural roads are on level hard sandy plains or are dirt roads following old mountain trails. It is difficult to encounter in Mexico, an agricultural region which has such an ample network of communications for the distribution of its products.

It is easily understood that a combination of excellent transportation facilities, an abundance of labor, excellent soil, a climate suitable for the cultivation of cotton and wheat, and ample water for irrigation should cause the development of an important agricultural region. Thus one of the most important agricultural regions of Mexico has developed—Laguna.

BOOK REVIEWS

COOKE, MORRIS L. *Brazil on the March*, Whittlesey House, McGraw-Hill Book Company, New York. Price $3.00.

Our American people have never been so generally interested in a South American nation as they now are in Brazil. Not only have they appreciated the cordial and practical support that Brazil has given them in this great World War, but they have felt that Brazil is really friendly and sincere in her relations with our country, not only in trade but in political and cultural fields as well. Most of the South American republics have been only lukewarm, or at best, passive in their support of America's struggle to maintain freedom and justice in the world. All the Spanish American Republics (and with the exception of Brazil, they are all Spanish in their origin, their culture, and their sympathies) have, for good reasons, been distrustful and suspicious of the United States ever since the Spanish American War. They have been fearful of America's imperialistic power; even though they might have conceded that the United States was not seeking territorial aggrandizement, they were all convinced that commercial and political dominance in the Western hemisphere was the goal of the United States government.

Brazil has not been so suspicious of the United States nor so unfriendly, partly because its people did not share the attitude of the Spanish American nations, and partly because the trade between the United States and Brazil was much more satisfactory, in that the products of the two countries were chiefly complementary rather than competitive. United States' interest in the Andean Republics were fundamentally exploitive, and American vested interests in the mineral resources of some of those countries, in many cases, proved irksome to the people. The relationships between Brazil and the United States in trade have been largely reciprocally helpful.

The exigencies of war have enforced a closer coöperation between the two countries and induced a more cordial friendship between them than ever before. Our people of the United States consider that, on the whole, Brazil has been forthright and friendly in her support of American policies. They are eager to learn more about this country that they have learned to like, and consequently the new book by Morris Cooke, written with the purpose in mind of interpreting Brazil's history and aspirations, and promoting even more friendly and helpful relations between the two countries comes at an opportune time. The people of America are very much interested to learn that Brazil is rapidly industrializing herself. She has established 15,000 factories in three years and put into operation her first modern steel plant. She is the fourth largest country in the world, larger even than the United States. She is rich in iron ore and other valuable mineral resources, and though lacking in coal, possesses great reserves of hydroelectric power, and may eventually be found to have great reserves of petroleum.

"Brazil on the March" presents clearly and succinctly the facts and statistics that the average American citizen should have at hand, and interprets them in terms of activities and industries, both developed and potential, for the present as well as the future. It is one of the best books on Brazil that has come from the press in recent years. It should be on the shelf of every American interested in South American cultural relations, trade relations, or political relations, with the United States. The book includes the essential materials requisite for a rather comprehensive knowledge of Brazil's resources and the opportunity for their development, and in the closing chapters points out some of the ways in which the United States and Brazil can work together for their mutual good. The book is not too long for quick reading and not too involved for easy reading. It represents an honest attempt to present to the people of the United States a compact and practical compendium of material needed for an appreciation of Brazil's present position and Brazil's future potentialities.

CHAPPLE, ELIOT D. AND COON, CARLETON S. *Principles of Anthropology*, Henry Holt and Company, New York.

Anthropology, for the past quarter century at least, has become increasingly geographic in its point of view, and increasingly conscious of the significance of man's adjustments to his environment as the motivating force for the development of his culture. In Chapple and Coon's "Principles of Anthropology," the geographer finds innumerable examples of the application of his discipline and technique, of his facts and principles, applied to the interpretation of man's activities and relations.

As the authors state in their preface, the book is an attempt to describe explicitly and systematically the principles of anthropology as we know them in the year 1942, principles that have been tested on material both from primitive groups and from our own civilization. They assert that the interpretations which they have made, consist of objective descriptions of the facts; that they have made no assumptions about human behavior which they cannot verify; and that they have discarded the subjective interpretation of others. They have achieved remarkably well the object which they set forth as the purpose of their book, and have established a new base upon which those interested in anthropology and its related subjects, like sociology and anthropogeography may build a systematic structure of fact and principle, explanation and interpretation.

Their book contains a wealth of geographic material, systematically arranged and organized, and of significant interest to the geographer. Any geographer to whom the book is accessible, and who makes use of the wealth of fact and interpretation that it includes, will clarify and expand his own knowledge, and be stimulated by the multitude of original and interesting ideas which the authors present. The book is large

and inclusive, but remarkably compact in its material The authors have been careful and critical in their selection of material and have used almost entirely sources which represent original research. Though of course the point of view is anthropological and the greater portion of the text is written primarily for the anthropologist, the geographer, the economist, the sociologist, and the average citizen will find a great deal to interest him in the content of this very valuable book.

There is nothing comparable with it in its clarity, its inclusiveness, its richness of material, and its skill in organization, available today in such up-to-date form. From every point of view it is highly satisfactory. Few men would have undertaken, or completed so successfully, such a valuable work. It deserves widespread use as textbook in its own field, as reference book for a half a dozen other fields of study and research, and as source of information on a most interesting subject for the layman. It is printed in clear type on good paper and bound well. It has an excellent index, a good reading list, and a satisfactory glossary. Only a captious and expert critic could find any fault with it.

WICKIZER, V. D. *Tea Under International Regulation*, Food Research Institute, Stanford University, California. Price $2.50.

Tea is a rather specialized and technical subject in the field of geography. The geography of tea would accordingly be a highly specialized part of the field of economic geography. Tea under international regulation becomes a still more limited field, in which only the specialist would have a major interest; but as an example of the technique and discipline of geography, particularly in the economic field, this book "Tea Under International Regulation" is valuable and interesting to the layman as well as the specialist. It also presents in detail an excellent example of the growing importance of cartels, and valorization agreements among the peoples of the world, particularly in products that enter into world trade.

As the title of the book indicates, the text is primarily concerned with international regulation of tea production, and the tea trade; but there is a great deal of general information regarding tea in the opening chapters, as for instance, "Characteristics of the Tea Industries," "Tea Culture and Marketing," "World Production and Exports," and "Demand and Tea Consumption."

Tea is the world's most widely used beverage. It enjoys greatest popularity in the United Kingdom and the British Dominions, and is also consumed extensively in the Orient and elsewhere, just as coffee is most popular in the United States, the Scandinavian countries, and in Central Europe, and is consumed extensively in the Levant and neighboring parts of Africa and Europe. The British Empire is by far the most important market of the world for tea moving in international trade. Russia consumes a great deal of tea but produces considerable of its own supply. The production of tea is dependent upon distinctive and interesting attributes of the environment in which it is successfully grown.

The general characteristics of tea culture, tea trade, and tea markets are briefly but ably presented in the book. The history of international regulation of the tea-trade is fully and comprehensively discussed. It is a book that every economic geographer will wish to have on his reference shelf.

FIFIELD, RUSSELL H., AND PEARCY, G. ETZEL. *Geopolitics in Principle and Practice*, Ginn and Company.

The world has become a-weary of geopolitics. The word itself, useful and significant enough in its proper setting, has become a shibboleth of modern geography and modern political science far beyond any useful or sensible purpose, except perhaps to sell books and confuse clear thinking. The study which the term has been extended to embrace has a much better foundation and structure in political science than it has in itself.

The book "Geopolitics in Principle and Practice" is perhaps as good as any that deals with the subject, brilliantly and interestingly but somewhat superficially written. While the sudden interest in the pseudoscience geopolitics was at fever heat the book was justified, and probably sold well. It probably helped a good many persons come to some definite conclusion as to what the term means; but in the light of clearer, more sensible judgment it cannot have a great deal of value, either as a textbook or as a reference book.

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The April issue of Volume 20 contains the following articles:

Vegetable Production in the Northern Everglades, L. LeMar Stephan, State Teachers College, Troy, Alabama.
Graphic Summary of Trade Between the United States and the Other Americas, Wallace W. Atwood, Clark University, Worcester, Massachusetts.
British Railways and Motor Roads in the Middle East, 1918–1930, Morton B. Stratton, Denison University, Granville, Ohio.
Land Utilization in the Middle Grand River Valley of Western Ontario, Chun-fen Lee, Harvard University, Cambridge Massachusetts.

The January issue includes:

Meeting an Emergency in Trade, Wallace W. Atwood, Clark University, Worcester, Massachusetts.
The Cotton Belt of North Carolina, Franklin C. Erickson, University of North Carolina.
Czech Farmers in Oklahoma, Russel W. Lynch, U.S.N.R., Oklahoma A. and M. College, Stillwater, Oklahoma.
The New Bright Tobacco Belt of North Carolina, Parnell W. Picklesimer, East Carolina Teachers College, Grenville, North Carolina.
The Bulb Industry of Western Washington, J. P. Galvin, U.S.N.R., University of Washington.
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Cement Production and Trade on the Great Lakes, Paul Cross Martin, Michigan State College.
Dairying in the South, Halene Hatcher, Map Division of O.S.S., Washington, D. C.
Path of Settlement and Distribution of the Population of Maine, Charles B. Fobes, Portland, Maine.
Cotton in the Economy of Mexico, Lorene A. Garloch, University of Pittsburgh, Pennsylvania.

The October issue of Volume 19 contains the following articles:

Pocatello, Idaho As a Railroad Center, Robert Wrigley, Jr., Research Planner, Chicago, Illinois.
Bulgaria's Modes of Transport, Kimon A. Doukas, Indiana University, Bloomington, Indiana.
The Spanish Moss Industry of Louisiana, C. C. Aldrich, M. W. De Blieux, and F. B. Kniffen, Louisiana State University.
The Migration and Settlement of Detroit Mexicans, N. D. Humphrey, Wayne University, Detroit, Michigan.
The Geography of Crab Orchard: A Submarginal Area in Southern Illinois, John L. Page and Eugene Mather, University of Illinois, Urbana, Illinois.
Current Aspects of American Agriculture, William I. Myers, New York State College of Agriculture, Ithaca, New York.
An Economic Future for Japan, George D. Hubbard, Oberlin College, Oberlin, Ohio.
The Industrial Development of the Allegheny Valley of Western Pennsylvania, E. Willard Miller, Western Reserve University, Ohio.
Our Middle American Trade, S. T. Emory, University of North Carolina.
The Tung Region of China, Yen Chiang-kwoh, Chungking, China.
Carnauba Wax in United States–Brazilian Foreign Trade, Grace Beckett, University of Illinois.
An Isarithmic-Dot Population Map, John W. Alexander, U.S.N.R., University of Illinois.

The July issue includes:

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